THE Petroleum Engineer

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AUGUST, 1953 • VOLUME XXV • NUMBER 8

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Consumers Could Be Regulated Out of Gas

THE United States Court of Appeals' recent decision that the Phillips Petroleum Company, as a producer and gatherer of natural gas, is subject to regulation by the Federal Power Commission, has caused uneasiness, to use a mild term, in many branches of the petroleum industry. Its effects could be far-reaching. Among the more important are the possible serious interference with the orderly development of natural gas resources, and the probability of higher prices to the consumer, although the legislation is to keep costs to the consumer at a minimum.

Within recent years natural gas has become a highly popular fuel because of its cheapness and convenience to use whereas once it was a commodity of considerable burden to the oil producer. As such, bidding for supplies is extremely active. The seller, who is the producer, now has three potential markets for his product. He can use it himself in his producing, refining, and manufacturing operations, he can sell it to a pipe line, or he can sell it to industry in the area in which it is produced.

If the consuming public generally speaking is to have any of this gas it must be taken to them by pipe line. Under the recent ruling, however, pipe lines are at a disadvantage in trying to buy gas. Industry in producing areas has become a serious competitor of pipe lines in the matter of purchasing supplies. There are numerous industrial plants on the Gulf Coast of Texas, for example, each of which consumes as much gas in a year as the City of Detroit. Some of the large sellers of gas are disposing of as much as 40 per cent of their production to this intra-state source.

Indeed, it is logical to think that the producer would prefer to sell his gas in this way rather than contract it to a buyer (the pipe line) who would involve him in complications and uncertainties inherent in federal regulation. Might this mean an eventual shortage in some consuming areas, or payment of a premium by pipe lines to procure necessary supplies? The latter result, obviously, would defeat the whole purpose of the law.

Another factor to consider is the possibility of creating a situation that will interfere with orderly development of natural gas reserves and also result in a higher cost for gas at its source. A regulated price based on the cost of production must take into consideration high cost production of inefficient operators as well as costs of efficient operators. In many cases this would result in increased costs to the consumer.

From the standpoint of public welfare, more is to be gained by permitting maximum freedom in the finding and developing of natural gas reserve. The greater gas reserves become, the better the position of the consumer. Regulation of the producer in whatever manner, it seems clear, will tend to make natural gas more expensive.

Ramifications of the subject are many, and in some instances are not clearly defined. Next month *The Petroleum Engineer* will publish an article by an unquestioned authority, which will give the complete background of the Phillips case and discuss the many facets of this exceedingly important subject.—F.H.L.

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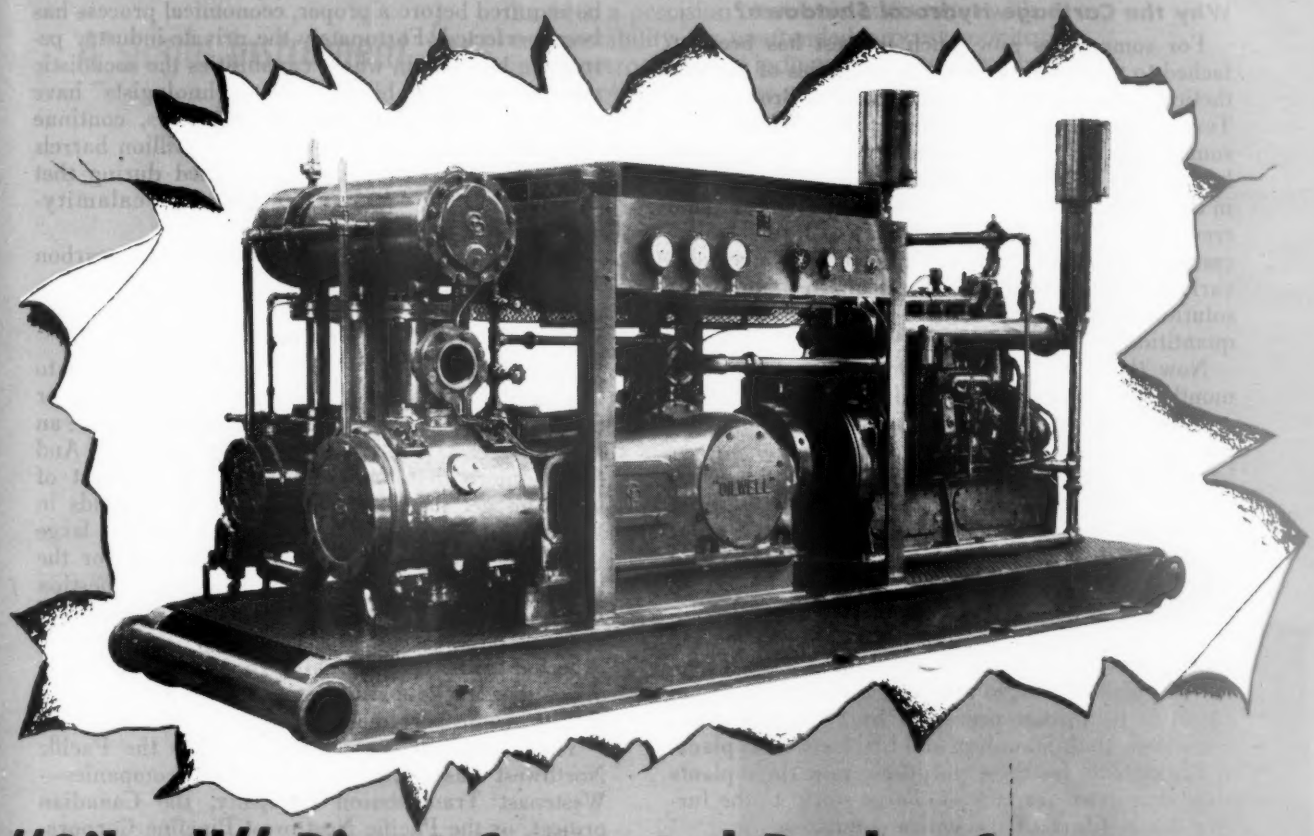

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With the EDITORS.....

Why the Carthage Hydrocol Shutdown?

For some years now much interest has been attached to the money-consuming activities of the synthetic gasoline-from-natural-gas plant at Brownsville, Texas. Starting out with a few million dollars, with some eight oil companies interested, it expanded largely via RFC funds to spend an amount reportedly in the neighborhood of $38,000,000 to build a plant credited to yield 7000 bbl per day of liquid hydrocarbons, largely in the motor fuel boiling range; also various oxidation-product chemicals in dilute water solution, it is understood, and in near-astronomical quantities.

Now the plant has been shut down "for three months for repairs, etc." according to officials, idling at least a part of the operating staff of 430. After making intensive studies of the same general process in a large-scale pilot plant at its Tulsa, Oklahoma, research laboratory Stanolind Oil and Gas Company ceased and desisted in its plans to build a similar plant, or one for a similar purpose, at least, in a southwest Kansas gas field, but decided to undertake the job of concentrating the huge volumes of solution of oxidized hydrocarbon by-products from the main sythesis reaction, alcohols, aldehydes, acids, ketones, glycols, etc., to put these materials into condition to be further processed by U. S. Industrial Chemicals. Both Stanolind and USI have built plants at Brownsville for these purposes; now these plants must shut down for lack of charge stock, to the further discomfiture of the entire enterprise.

Although shutdown period of three months is announced, the opinions of commentators is, as one chemical journal editor has stated it, "The plant will be closed down for at least three months — and likely much longer." Another observation is that "the plant has been shut down for major repairs and installation of new equipment to obtain design capacity, but no estimated date for resumption of operation is given."

According to advices the plant has not produced more than 10 per cent per day of its announced daily capacity, which if true indicates the necessity for radical changes in design and layout, equipment, etc., to reach the planned-for goal. Efforts by German firms pre-War and during the war to make this Fischer-Tropsch synthesis work out economically met largely with failure. American engineers have stated that this failure is traceable largely to the fixed-catalyst-bed design, making excess head removal and temperature control impractical. The so-called fluidized catalyst bed, so successful in catalytic cracking operations, was adopted in principle for the synthesis, and better results have been expected.

It is considered a "sewing-circle secret" that additional money is being sought to permit redesign and expansion of the unit and process. Just what rejiggering is called for of course has not been announced. It is even yet too early to consider the solution of this problem impractical; many technologists in the industry today remember the troubles, headaches, mistakes and failures in development of thermal cracking, before the process became successful. This problem appears to be much more involved and considerably more time and money may be required before a proper, economical process has been perfected. Fortunately the private-industry petroleum hunters, in whose capabilities the socialistic governmental spellbinders and "technologists" have shown so little confidence of late years, continue their way by finding a few hundred million barrels more oil each year than is consumed during that time, confusing and confounding the calamity-howlers.

Anybody else have a solution to hydrocarbon synthesis? — ALF.

From Whence Shall It Come?

Natural gas for the Pacific Northwest appears to be inevitable, whether the source is Canada or Southwestern United States. Everyone with an opinion seems to be "getting in on the act." And there's more than one opinion on the subject of where to get the gas: Canada? Or U. S. fields in Wyoming and New Mexico? In either event, large sums of U. S. dollars would be expended for the transmission facilities, which brings up the question of gas supplies to both investors and consumers. Consumers will need plenty of gas, with demands expected to increase annually. Investors want assurances there will be sufficient supplies to make the transmission operation financially successful.

The battle between who shall serve the Pacific Northwest has boiled down to two companies—Westcoast Transmission Company, the Canadian project, or the Pacific Northwest Pipeline Corporation, the U. S. project. Hearings on the proposed natural gas service to the area in question are continuing in Washington before the Federal Power Commission. There is widespread interest elsewhere, too.

Basically, the questions to be answered by proponents of both pipe lines are cost, supply, and pricing.

Those favoring the Westcoast program say the Canadian line will have lower initial and operating costs. Natural gas from Canadian sources will have a lower delivered price than U. S. gas, based on transmission costs. And they point out that Canadian officials have assured prospective buyers that supplies will be sufficient.

Supporters of the Pacific Northwest Pipe Line have made an issue of the investment, pointing out that all money spent on their system would be spent within the United States. Additionally, they ask, does the Peace River area have a sufficient supply of natural gas to serve the Pacific Northwest region for an initial 20-year period, and what reserves are are there for the following years? The questions of policing of prices and assurances of continuous and adequate supply of gas are also raised in reference to Canadian gas.

Questions of cost, investments, supply and pricing are important. Governments do change, and perhaps development of industries in Canada might alter the official outlook on supplying gas to U. S. consumers when Canadian markets are available. On the other hand, demands from other U. S. areas for gas from New Mexico and Wyoming might limit those sources of supply.—D.H.

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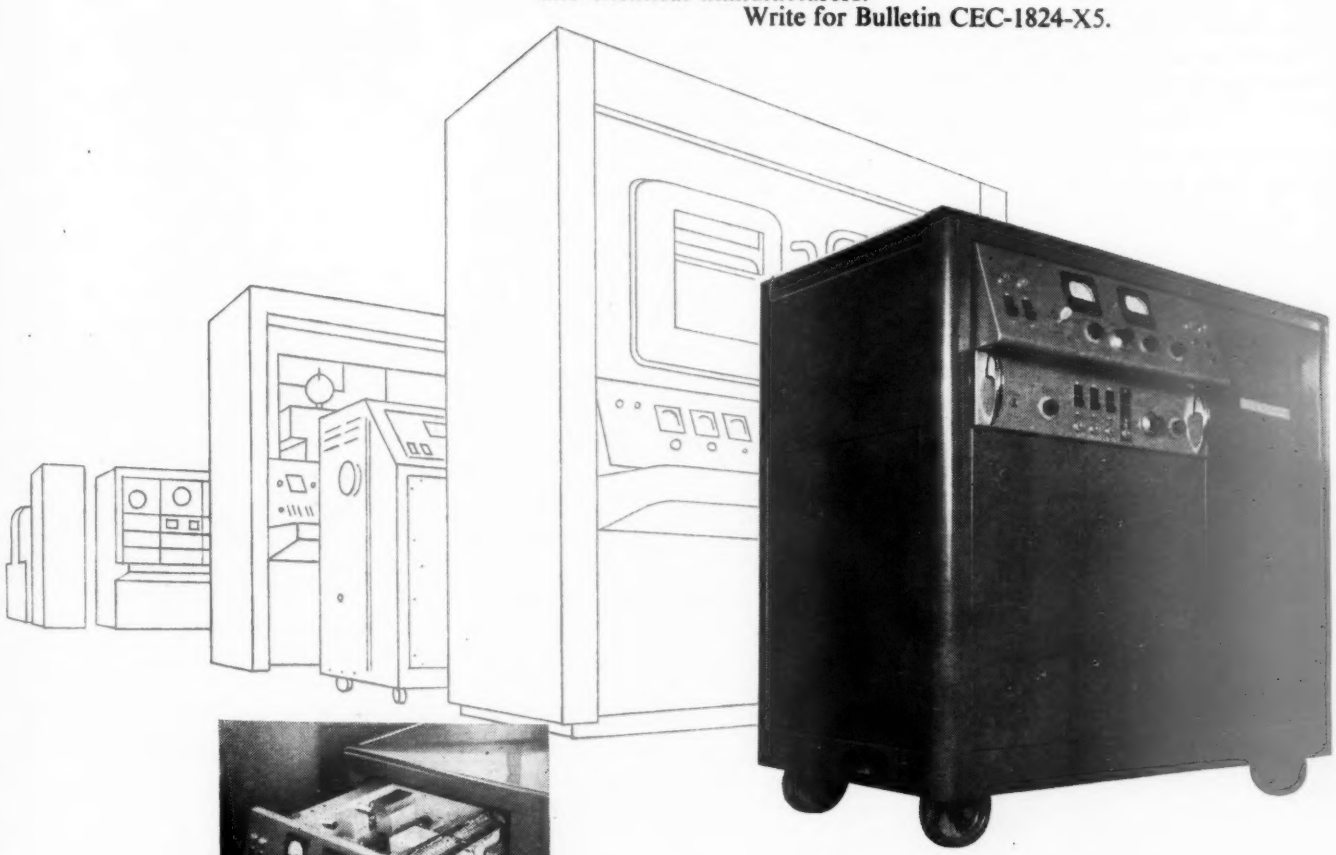
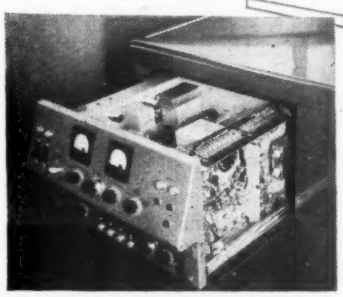
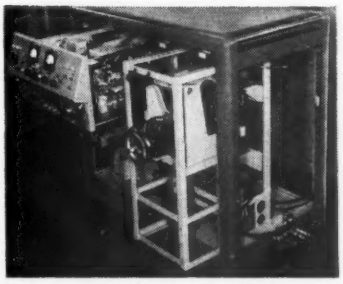
Write for Bulletin CEC-1824-X5.





All components are accessible: either by removing side panels or by pull-out chassis containing circuits and controls.



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HIGHLIGHTS IN OILDOM

Oil Exploration Hampered

Oil and gas exploration in public lands states is still being hampered by "lower echelon bureaucrats", according to H. B. Gernert, president of the Rocky Mountain Oil and Gas Association. Geinert stated in an interview that although leaders in the Department of Interior are fine men, business men, there are "still a lot of lower echelon hold over bureaucrats" in Washington who simply do not understand western land problems.

IPAA Upholds Oil Price Rise

The Independent Petroleum Association of America has reported that crude prices since 1947, date of previous increase, are up only 9.3 per cent, whereas the cost of finding oil has increased 35 to 40 per cent. Steel prices are 43 per cent higher, not including the most recent advance for that material. Worker wages have gone up 40 per cent.

Water Level Down

A dropping water level in Lake Texoma is permitting much drilling on dry land in the Big Mineral field of Grayson County, North Texas. Normal water level is 620 ft above sea level, and present level is 604 ft. Nineteen locations have been staked in this field. New water sources in western and central Kansas are being sought and developed by drilling contractors, oil companies, and geologists following an appeal from Governor Arn of Kansas.

Gas Customers Pass Firms

Commercial gas customers in the United States outnumbered retail business establishments in the postwar period—1946 to 1952. Since 1941 commercial gas sales have nearly tripled, with much of the growth due to the expanded food service field. Americans spend more than $15 billion per year on meals consumed outside the home. Nine out of 10 of these meals are cooked with gas, the AGA reports.

Good Public Relations Sought

The oil industry must recognize public relations as everyone's job, S. F. Bowlby, vice president, Shell Oil Company, told nearly 100 Southern California oil men at a dinner at the Petroleum Club in Los Angeles.

Bowlby, in charge of exploration and production for Shell for the Pacific Coast and Rocky Mountain regions, was guest speaker at the award dinner of Southern California Oil Information Committee.

Quoting the definition of public relations by H. M. S. Burns, Shell Oil Company president, "Live right and let people know about it," Bowlby said, "All of us in the oil industry must undertake to live right as individuals. we must see that the business interests we represent do right in their dealings with the public, we must work together to enable the industry as a whole to live right, and we must help find the ways and means of letting the public know we live right in a way it will understand and appreciate."

New Write-Off Bill Up

A new bill aimed chiefly at aiding small business has been introduced to the Senate by Homer Capehart (R—Indiana). The bill would allow any person or company to write off in five years the cost of any capital investment acquired after December 31 of this year. Companies would be allowed to keep larger portions of their profits in the first years of operation. Administration tax experts are also considering depreciation of property for tax purposes. Treasury Secretary George Humphrey has announced tax officials are studying ways of giving businessmen more leeway in determining how fast they write off plant and equipment.

School Teachers in Industry

Seven scientists and engineers from faculties of Midwest universities have been chosen to work in summer research work by Standard Oil of Indiana. Standard also announced that about 20 graduate students were also hired for summer week.

New Well for Benedum Birthday

Discovery of a new oil field was the 'birthday cake' for M. L. (Mike) Benedum on his 84th birthday. One of the world's greatest wildcatters, Benedum's new well came in in Knox County, Texas, flowing 75 bbl an hour, in an area selected by Benedum two years ago. Benedum celebrated his birthday in Pittsburgh, Pennsylvania, by greeting about 70 of his close friends at a birthday luncheon.

Arkansas Attacks Oil Law

Arkansas has filed an official complaint challenging the constitutionality of the offshore oil act passed by the senate recently and signed by the President in May. Tom Gentry, Arkansas Attorney General, said the bill, which give the states control of the oil and other resources under the waters off their coasts seaward to their "historic boundaries" was "an unwarranted and invalid attempt to abdicate the sovereignty of the United States to a few of the states." A "separability clause" attached to the bill provides that if the courts rule Congress does not have authority to turn title of the submerged lands over to the states, then the states will still have authority to administer oil operations in their territories and to collect royalties, etc.

More Leasing Acreage Sought

A measure to raise acreage that may be leased or optioned for oil development by a single party in any one state has been introduced by Senator Barrett (R—Wyoming). The new bill would place the amount of land that could be held under a single lease to 46,080 acres, and the amount that might be optioned from 100,000 to 200,000 acres. Present number of acres that may be leased is 15,360. Option terms would be increased from two to three years.

Museum Displays Grow

The list of exhibits given to the National Oil Museum for permanent display is still growing. Exhibits and working models including the geological, petrochemical, and pipe line system displays, represent a cost in excess of $150,000, according to LuCelia Wise, second vice president of the Museum. Numerous exhibits displayed at the International Oil Show have been given for placement in the Museum.

Competitive Bidding Urged

A bill amending the mineral leasing law to require bids for leasing oil and gas deposits not in any known geological structure of a producing field has been introduced. Legislation was recommended by Senator Williams (R—Delaware) to require competitive bidding for leasing certain federal land for oil and gas exploration.

Oil Firms Grant Pay Rise

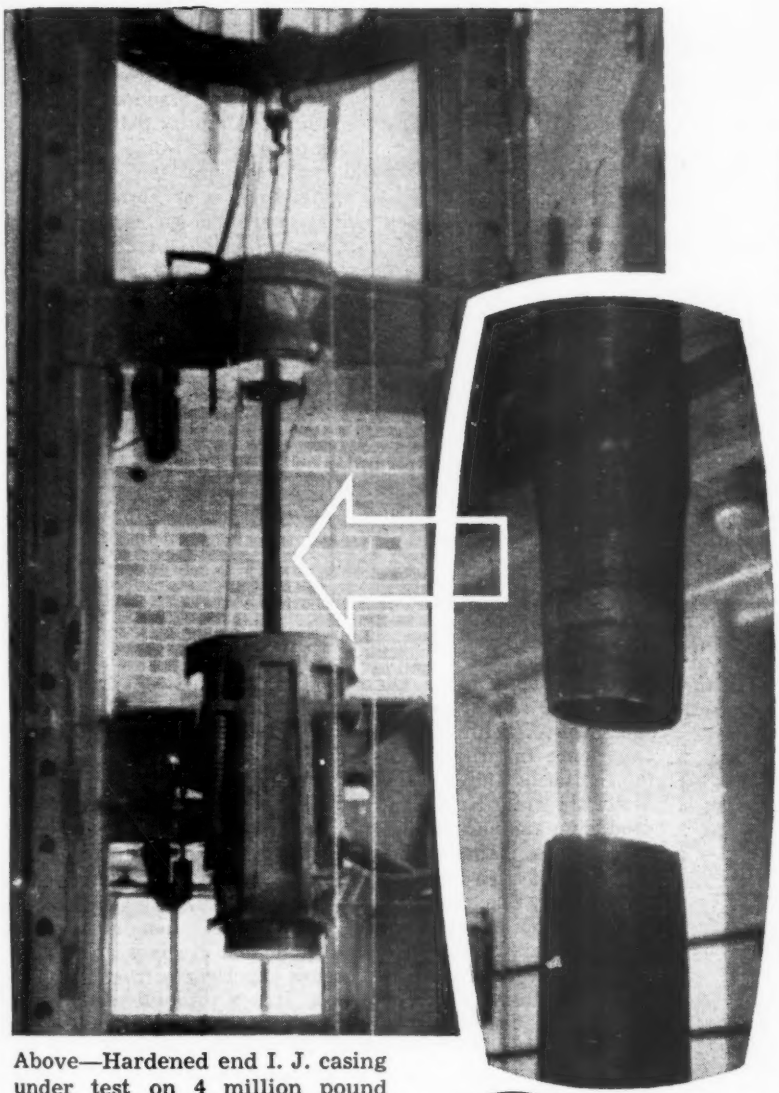
Numerous oil companies have granted 4 per cent wage and salary increases to their non-union employees. On a cents-per-hour basis this will amount to approximately 8 to 9 cents. Such increases keep the oil industry salaries and wages at a level with any industry and ahead of most. It is feared, however, that should this policy of applying such increases be used as a "pattern" it will work a hardship on smaller refiners. The OWIU (CIO) locals has charged that the companies are in league with one another against the union, and disavowed any plans for industry-wide bargaining. It has been noted, however, that when one company grants a wage increase, such an increase has been used as a pattern for other companies.

Freer Trade Urged

President Eisenhower told a news conference recently that he is not in favor of a law limiting oil imports. He said he had not had enough time to study the reciprocal and foreign trade programs and felt that a greater study should be made before the law is changed. He said that on the whole he believed we should have a freer trade in the world.

XUM

EXTRAS *that make it* BETTER



Above—Hardened end I. J. casing under test on 4 million pound testing machine at University of California. Closeup at right—Note that tested pipe broke in body, away from threaded connection.

Hardened Ends and API Threads on Youngstown Deep Well Casing

YOUNGSTOWN casing - Integral Joint and Threaded and Coupled - is produced with heat treated ends to meet the higher requirements of deep well drilling. The advantages are:

1. Controlled heat treating of ends assures homogenity of structure throughout the pipe wall.
2. Hardening makes upsets unnecessary, thus eliminates obstructions on the internal surface of the casing.
3. High joint strengths - meeting requirements of API Bulletin 5A-1 - are proven by repeated tests.
4. Integral joints improve long strings by eliminating half the threaded joints. Simplification also results as the same thread can be used for an entire string, heat treated on top, untreated on bottom. No crossover joints required.

For data on actual performance in the field, write or phone the nearest Youngstown District Sales Office.

QUALITY YOUNGSTOWN SERVICE

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OIL COUNTRY TUBULAR GOODS

THE YOUNGSTOWN SHEET AND TUBE COMPANY *Manufacturers of Carbon, Alloy and Yalay Steel*

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PIPE AND TUBULAR PRODUCTS - CONDUIT - BARS - RODS - COLD FINISHED CARBON AND ALLOY BARS - SHEETS - PLATES - WIRE - ELECTROLYTIC TIN PLATE - COKE TIN PLATE - RAILROAD TRACK SPIKES

PETROLIC PERSONALITIES

DICK SNEDDON

Mobile Barbecue Bands to Roam the West

For some years, we are told, there has been a group of oil men foraging around the oil fields of Texas and Oklahoma, with portable barbecuing equipment, doing a wonderful job of serving any deserving organization of oil people with luscious steaks, pit barbecue, and all the trimmings, whenever and wherever the occasion warrants. This coterie of purveyors is composed largely of oil executives who donate their services and merely do this sort of thing because they like it. Well, that is all very worthy and no doubt they will be interested to learn that their stimulating example has excited the development of a similar band in Ventura, California.

Ring leaders of this enterprise are Fritz Huntsinger, the fabulous prexy of the Ventura Tool Company, and George Ruggels, the CCMO production exceutive from up in the same area. These gentlemen, aided by sundry townsmen, many of whom are of the petrolic ilk, instituted an equipment committee some time ago, and we understand that it has just recently completed its work. They have assembled a plentiful assortment of tools and have a well accoutered trailer in which the essentials will be transported from place to place, while the principals move about in their Cadillacs and such.

Anyway, we had a letter from George the other day, stating that the gang is just about ready to demonstrate. If they do as well as they did when the Pioneers met in Santa Paula and Ventura a few years ago, they are a cinch to be in demand. Certainly, we wish Fritz, George, and all their associates in the mobile barbecuing business, the most of the best, and we unhesitatingly predict that when their plans become better known they will be busier than a blonde stoaway on a cruiser.

On the Oil Front
APE MAN
FAT GIRL
J-W SHOWS
HANK ROESSLER
"THOUGHT I'D BETTER ADD TO THAT COUNTER-WEIGHT, - GOT A HEAVY LIFT TO MAKE."

Overseas Delegate Returns with Pipes

We learn with more than ordinary interest that our erstwhile friend and associate, Norval Myers, has been transferred back to this country and will until further orders be officiating as deputy coordinator of refining activities for Standard Oil Company of New Jersey, a rather substantial entity that is, indeed, reputed to be the largest oil company in the world. Norval has been over in London, England, for the past four years more or less, functioning as managing director of Esso Petroleum Company, Ltd., a Jersey affiliate once known as the Anglo-American Oil Company, Ltd., where he has directed the construction of one of Europe's biggest refineries, at Fawley. In his new assignment he will have headquarters in New York and if he has any regards for his wallet, will steer clear of gin rummy encounters with such sharpies as Bill Beck, Joe Taylor, Hank McAdams, Lou Harrison, Ed Landgraff, and others of their ilk.

This warning, incidentally, is a service that, despite our nationality, we extend free to any of our friends who may be wandering into New Amsterdam without adequate preparation for what may follow. We might also mention here that even before he left for England, Norval Myers was one of these inveterate pipe smokers who accumulate more species of hay burners than are stocked by a Cheapside tobacconist.

Consultant Warbles Irish Come-All-Ye's

Jim McNeill, the petroleum engineer who has lately been serving the Tevis Morrow interests, has now opened his own consulting office in the Ohio Oil Building in Los Angeles. Jim spent some 17 years with Union Oil Company, later had several years with Wilshire Oil Company, and has had an interesting experience in production technology and economics, in both the California and Mid-Continent fields, as well as in the Rocky Mountain area. He is familiar with all aspects of oil and gas producing and accounting, and besides that is very nice people. Although he claims to be of Scottish descent, he has a weird collection of Irish "come all ye's" into which he has a tendency to break any time the occasion is right, or at least he thinks it is.

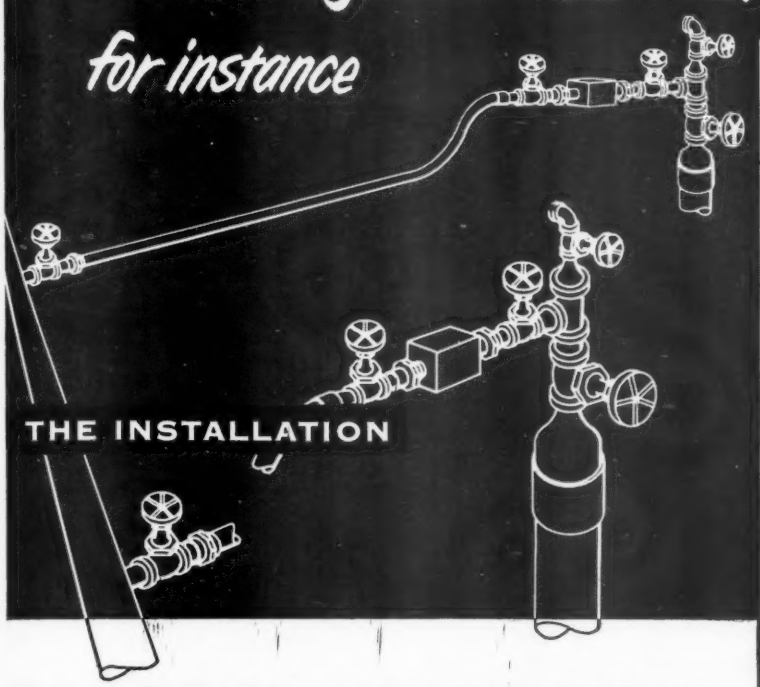
He is also a pretty sharp softball player—as long as his wind lasts—but his real forte is entertainment. He is a good story teller with a fine fund of yarns and experiences from which to draw, and he is an excellent host. It is a prideful recollection of our own distinctly bedraggled business career and something of which Jim is prabably profoundly ashamed, that we were once his boss. That, of course, was before he became famous and in the meantime we have failed entirely to capitalize on the association. By the way, Jim is going to be in the same office as Bill Geis, the noted playwright, petroleum consultant, and prexy of the Los Angeles Petroleum Club, who sold out some of his oil interests recently for a fairish stash of the long green, and is leaving about October for a year's vacation.

News of a Nautical Nature

Quite a few western oil executives were signed on as crew members of the competing yachts in the Honolulu race and are now down in the deep Pacific. Frixample, Howard Pyle, the Monterey Oil Company president, was one of the deck hands on the *Goodwill* which was first in but doesn't have a chance to win on the basis of handicaps. It was skippered by Walt Elliott, another well known oil man. Its navigator was John Hurndahl, president of Intex; and one of its most able able seamen was Don Greenlee, the Shell geologist.

As we write, Bill Stewart's *Chubasco*, skippered this time by Bill Junior, looks as if it has a good chance to capture the trophy, although there is one ship close enough yet to give him a contest. Aboard the *Chubasco* is Stan Natcher, the deep chested Standard of Cal executive, who has already sailed three or four times in this race under the Stewart banner. Bill has never won the trophy although he has crossed the finish line first, but this could be the time.

Valve Performance that Speaks for itself ...on Well Injection Service, for instance



THE INSTALLATION

In the Kansas field operations of a prominent oil company, with Crane Bronze Gate Valves on injection lines to wells for oil production by water flooding. Working pressure approximately 900 psi.

VALVE SERVICE RATINGS

SUITABILITY:	Best by test
FEATURES:	Hard, tough, nickel alloy disc
MAINTENANCE COST:	Routine care only
SERVICE LIFE:	Now in line more than 4½ years
OPERATING RESULTS:	Proper control of system
AVAILABILITY:	Crane catalog item—No. 624E

THE CASE HISTORY

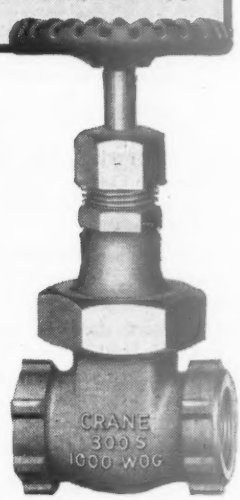
Originally, this well-flooding system was installed with plug valves which proved a severe handicap. Corroded by the salt water, the valves stuck so hard they couldn't be operated to cut in or shut off wells on the line.

Iron body valves also were tried, but gave no better results. They corroded and leaked, losing much needed pressure.

More than 4 years ago, Crane No. 624E Bronze Gate Valves were put on the system. Corrosion and leakage were eliminated. Valve operation became smooth, easy, positive—the way it should be. And, ever since, that's how these Crane valves have performed. No wonder this producer, like many others, has hundreds of them in similar service.

THE VALVE

Crane No. 624E gate valves have unusually heavy metal sections and are ruggedly constructed throughout for high pressure service. Body and bonnet are of Crane Special Bronze, a high-grade leaded tin bronze. Disc is of hard, tough Crane Nickel Alloy. Better Crane quality in every detail makes them last and last. Sizes up to 2 in. rated at 1,000 psi. W.O.G. See your Crane Catalog or ask your Crane Representative for demonstration.



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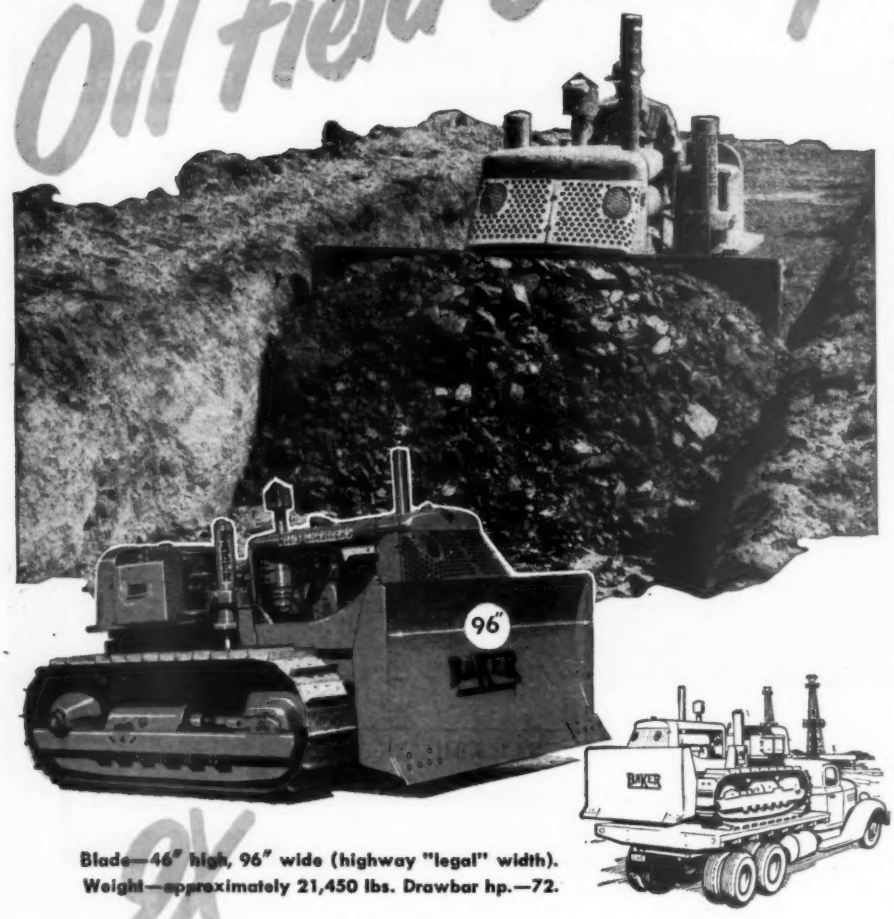
Oil Field Dozing



9X

Blade—46" high, 96" wide (highway "legal" width). Weight—approximately 21,450 lbs. Drawbar hp.—72.

OIL FIELD ACCEPTED . . . the new Baker 9X no-pushbeam Dozer, a powerful, compact 8 ft. Dozer that *moves*—on the job and over the road!

Load it on standard-width truck or trailer and haul it anywhere—over any highway—*legally.* Put it to work on any job—fire walls, slush or salt water pits, or any other field dozing—and watch it sock down deep and *fast,* down to 13" below ground-level with a *steeper* angle of approach. Pour on the power and see the famed Baker "roll-action curve" boil the dirt high. Flick the fingertip control and up comes the blade—*fast*—up to 37" above ground level. No loss of traction—bulk of 9X's weight "stands on the blade," for both tractor and dozer frame are *one integral unit.*

If you haven't seen the new 9X in action, contact your Baker, A-C Dealer today—ask for a demonstration, or write for Bulletin No. 896-B.

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Springfield, Illinois

Baker—The most *versatile* line of tractor attachments

Meetings

Aug. 17-19—**Society of Automotive Engineers,** international West Coast meeting, Georgia Hotel, Vancouver, B. C., Canada.

Aug. 31-Sept. 1—**Interstate Oil Compact Commission,** summer meeting, Northern Hotel, Billings, Montana.

Sept. 1-4—**American Institute of Electrical Engineers,** pacific general meeting, Vancouver Hotel, Vancouver, B. C., Canada.

Sept. 6-11—**American Chemical Society,** national meeting, Conrad Hilton Hotel, Chicago, Illinois.

Sept. 9-11—**Oil Industry Information Committee,** Cleveland Hotel, Cleveland, Ohio.

Sept. 9-11—**Pacific Coast Gas Association,** San Francisco, California.

Sept. 10-11—**Desk and Derrick Clubs of North America,** second annual convention, Cosmopolitan Hotel, Denver, Colorado.

Sept. 13-16—**American Institute of Chemical Engineers,** Fairmont and Mark Hopkins Hotels, San Francisco, California.

Sept. 15-16—**American Petroleum Institute,** Executive Committee, Greenbriar Hotel, White Sulphur Springs, West Virginia.

Sept. 16-18—**National Petroleum Association,** annual meeting. The Traymore, Atlantic City, New Jersey.

Sept. 21-22—**Natural Gasoline Association of America,** Fractional Analysis Seminar, Texas Hotel, Fort Worth, Texas.

Sept. 21-25—**Instrument Society of America,** 8th national instrument conference and exhibit, Sherman and Morrison Hotels, Chicago, Illinois.

Sept. 24-25—**Western Petroleum Refiners Association,** regional meeting, Henning Hotel, Casper, Wyoming.

Sept. 27-30—**American Society of Mechanical Engineers,** annual petroleum engineers conference, Rice Hotel, Houston, Texas.

Sept. 27-Oct. 2—**American Society for Testing Materials,** committee D-2 on petroleum products and lubricants, Shoreham Hotel, Washington, D. C.

Sept. 29—**National Petroleum Council,** Washington, D. C., 10 a. m.

Oct. 1-2—**Mid-Continent Oil and Gas Association,** Louisiana-Arkansas division, annual meeting, Roosevelt Hotel, New Orleans, Louisiana.

Oct. 4-6—**American Association of Oil Well Drilling Contractors,** annual meeting, Denver, Colorado.

Oct. 5-7—**Texas Mid-Continent Oil and Gas Association,** annual meeting, Rice Hotel, Houston, Texas.

Oct. 7-9—**National Association of Corrosion Engineers,** South Central Region annual meeting, Mayo Hotel, Tulsa, Oklahoma.

Oct. 8-9—**California Natural Gasoline Association,** 28th annual fall meeting, Ambassador Hotel, Los Angeles, California.

Oct. 8-9—**Illinois Institute of Technology,** conference on Industrial Hydraulics, annual meeting, Hotel Sheraton, Chicago, Illinois.

Oct. 8-11—**First International Engineers' Congress,** fostered by the Federation Internationale des Associations Nationales d'Ingenieurs, c/o A.N.I.A.I., Via Terme Diocvleziano, Rome, Italy.

Oct. 11-17—**Oil Progress Week.**

Oct. 19-20—**Independent Petroleum Association of America,** annual meeting, Hotel Texas, Fort Worth, Texas.

Oct. 19-21—**American Institute of Mining and Metallurgical Engineers,** Petroleum Branch fall meeting, Adolphus and Baker Hotels, Dallas, Texas.

Oct. 19-23—**National Safety Council,** annual congress, Conrad Hilton, Congress, Morrison, Sheraton Hotels, Chicago, Illinois.

Oct. 22-23—**Western Petroleum Refiners Association,** regional meeting, Garrett Hotel, Eldorado, Arkansas.

Oct. 23—**Natural Gasoline Association of America,** Southern Regional meeting, Blackstone Hotel, Tyler, Texas.

Oct. 24—**Natural Gasoline Association of America,** regional meeting, Blackstone Hotel, Tyler.

Oct. 26-28—**National Lubricating Grease Institute,** annual meeting, Edgewater Beach Hotel, Chicago, Illinois.

Oct. 26-29—**American Gas Association,** annual conference, Kiel Auditorium, St. Louis, Missouri.

Oct. 27—**Association of Consulting Chemists and Chemical Engineers, Inc.,** New York, New York.

Oct. 29-31—**Rocky Mountain Oil and Gas Association,** annual convention, Cosmopolitan Hotel, Denver, Colorado.

Nov. 2-4—**Society of Automotive Engineers,** National transportation meeting, Conrad Hilton Hotel, Chicago, Illinois.

Nov. 2-4—**American Petroleum Credit Association,** 29th annual conference, Biltmore Hotel, New York, New York.

Nov. 3-4—**Society of Automotive Engineers,** national diesel engine meeting, Conrad Hilton Hotel, Chicago, Illinois.

Nov. 5-6—**Society of Automotive Engineers,** national fuels and lubricants division, Conrad Hilton Hotel, Chicago, Illinois.

Nov. 9-11—**The Geological Society of America,** annual meeting, Royal York Hotel, Toronto, Ontario, Canada.

Nov. 9-12—**American Petroleum Institute,** annual meeting, Conrad Hilton Hotel and Palmer House, Chicago, Illinois.

Nov. 12—**American Petroleum Institute,** Executive Committee, Conrad Hilton Hotel, Chicago, Illinois.

Nov. 19—**National Industrial Conference Board,** Schenley Hotel, Pittsburgh, Pennsylvania.

Nov. 20—**Natural Gasoline Association of America,** Panhandle-Plains Regional meeting, Herring Hotel, Amarillo, Texas.

Nov. 21—**Natural Gasoline Association of America,** regional meeting, Herring Hotel, Amarillo, Texas.

Nov. 29-Dec. 4—**American Society of Mechanical Engineers,** Statler Hotel, New York, New York.

Nov. 30-Dec. 5—**Exposition of Chemical Industries,** 24th biennial run, Commercial Museum and Convention Hall, Philadelphia, Pennsylvania.

Dec. 6-8—**Chemical Specialties Manufacturers Association, Inc.,** annual meeting, Mayflower Hotel, Washington, D. C.

Dec. 13-16—**American Institute of Chemical Engineers,** annual meeting, Hotel Jefferson, St. Louis, Missouri.

Dec. 28-29—**American Chemical Society,** division of Industrial and Engineering Chemistry, Univrsity of Michigan, Ann Arbor, Michigan.

NOMADS TO MEET

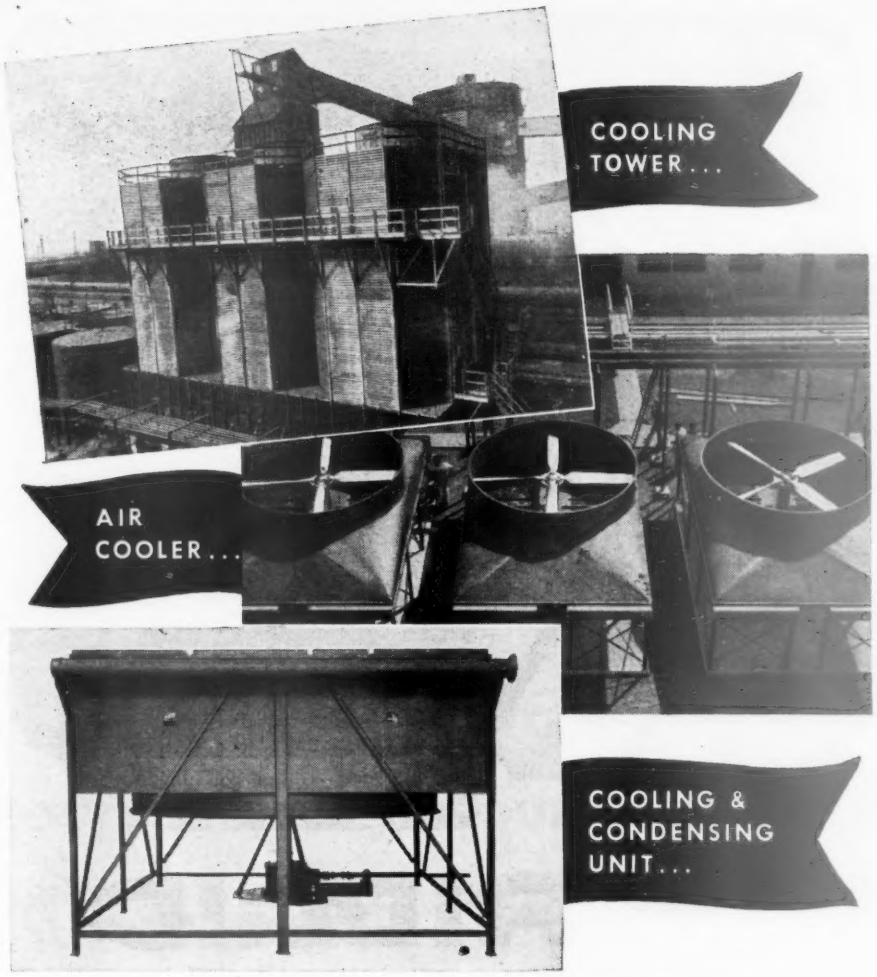
New York, N. Y., Chapter, First Monday of the Month, Louis Sherry's New York. Secretary, O. B. Latrobe.

Houston Chapter, Second Monday of the Month, Ye Olde College Inn, Houston, Texas. Secretary, Harry E. Estes.

Los Angeles Chapter, Second Wednesday of the Month, Jonathan Club, Los Angeles, Calif. Executive Secretary, Wallace A. Sawdon.

Tulsa Chapter, Third Friday, "After Five" Room, Hotel Tulsa. Secretary, Gilbert Swift.

Dallas-Fort Worth Chapter, Dallas, Texas. First Monday of the Month. Secretary, M. W. Hiltpold.



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Aeromaster blades are protected against mild acids and alkalies, abrasion, all weather conditions, by a special *Aeroloid* blade coating, exclusive with Aeromaster. Aeromaster Fans are fully guaranteed . . . many models, ranging from 5 to 24 ft. diameters, with 4, 6, or 8 blades per fan—capacities up to 1,000,000 cfm. As original equipment or for replacement, Aeromaster Fans are tops for long-lasting, reliable operation at less cost!

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Look for the wrench with that guarantee label to make sure you get the extra-easy work and extra durability that have made RIGID the world's most popular wrench.

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Save work and money—buy genuine RIGIDs at your Supply House.

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RIGID

Work-Saver Pipe Tools

1954

Jan. 11-15—**Society of Automotive Engineers,** annual meeting and engineering display, Sheraton-Cadillac and Statler Hotels, Detroit, Michigan.

Jan. 18-22—**American Institute of Electrical Engineers,** winter general meeting, Statler Hotel, New York, New York.

Jan. 21-22—**American Industrial Conference Board,** Astor Hotel, New York, New York.

Feb. 8-9—**Missouri Petroleum Association,** annual convention, Chase Hotel, St. Louis, Missouri.

Feb. 26—**Natural Gasoline Association of America,** Permian Basin Regional meeting, Lincoln Hotel, Odessa, Texas.

March 3-5—**American Petroleum Institute,** Southwestern District, Rice Hotel, Houston, Texas.

March 8-10—**American Institute of Chemical Engineers,** Statler Hotel, Washington, D. C.

March 15-19—**National Association of Corrosion Engineers,** annual meeting, Kansas City Municipal Auditorium, Kansas City, Missouri.

March 17-19—**American Petroleum Institute,** Mid-Continent District, Skirvin Hotel, Oklahoma City, Oklahoma.

March 25—**National Industrial Conference Board,** Skirvin Hotel, Oklahoma City, Oklahoma.

March 25-26—**New England Gas Association,** Statler Hotel, Boston, Massachusetts.

April 8-9—**American Petroleum Institute,** Rocky Mountain District, Townsend, Gladstone and Henning Hotels, Casper, Wyoming.

April 12-15—**Society of Automotive Engineers,** national aeronautic meeting, Statler Hotel, New York, New York.

Apirl 21-23—**Natural Gasoline Association of America,** annual convention, Baker Hotel, Dallas, Texas.

May 2-4—**Independent Petroleum Association of America,** midyear meeting, Cosmopolitan Hotel, Denver, Colorado.

May 3-5—**American Petroleum Institute,** Lubrication Committee, Skytop Lodge, Skytop, Pennsylvania.

May 10-12—**American Petroleum Institute,** Division of Transportation, Products Pipe Line Conference, Warwick Hotel, Philadelphia, Pennsylvania.

May 10-13—**American Petroleum Institute,** Division of Refining, mid-year meeting, Rice Hotel, Houston, Texas.

May 10-13—**Liquefied Petroleum Gas Association,** annual convention, Conrad Hilton Hotel, Chicago, Illinois.

May 16-19—**American Institute of Chemical Engineers,** Conrad Hilton Hotel, Chicago, Illinois.

June 17-19—**American Petroleum Institute,** Division of Production, Eastern district, Greenbrier Hotel, While Sulphur Springs, West Virginia.

Sept. 12-16—**American Institute of Chemical Engineers,** Colorado Hotel, Glenwood Springs, Colorado.

Sept. 28-29—**Texas Mid-Continent Oil and Gas Association,** annual convention, Baker Hotel, Dallas, Texas.

Oct. 11-14—**American Gas Association,** Atlantic City, New Jersey.

Oct. 26-27—**Society of Automotive Engineers,** national diesel engine meeting, Statler Hotel, Cleveland, Ohio.

Nov. 1-2—**Independent Petroleum Association of America,** annual meeting, Shamrock Hotel, Houston, Texas.

Nov. 4-5—**Society of Automotive Engineers,** national fuels and lubricants meeting, Mayo Hotel, Tulsa, Oklahoma.

Nov. 8-11—**American Petroleum Institute,** 34th annual meeting, Conrad Hilton Hotel and Palmer House, Chicago, Illinois.

SEARCH for oil goes on. *We have not run out of new potential areas.*

The Petroleum Engineer
August, 1953

U. S. Petroleum Supply Can Draw Upon Wealth of Resources and Resourcefulness†

A. C. RUBEL

AN oil producer should feel very much at home with a group of mechanical engineers, inasmuch as the development of the oil industry in many of its phases has always gone hand in hand with the contributions of the mechanical engineer and the metallurgist.

I can vividly remember in the early twenties when a 5000-ft well was something to talk about, and my own first bid to fame came when my company drilled the "deepest well in the world," and my picture appeared in the trade magazines holding 6-in. of badly fused and completely useless core under the caption "Core from the World's Deepest Well."

This hole was 7321 ft as I recall, and of course dry as a bone as are all record wells. The hour of fame was short lived as the depth record has been pushed progressively downward to a present measurement of 20,521 ft, with no real limit in sight except a financial one.

When we consider the type of equipment used in our old hole, I firmly believe it was a more difficult feat then than the 20,000-footers of today with the equipment and techniques now available.

I am asked to discuss with you the future of the industry as it affects you and me, and I wonder how many of you realize the extent to which the products of our industry have entered into your everyday life and how dependent you have become upon them.

†Presented before the meeting of American Society of Mechanical Engineers, June 30, 1953.

The Author

A. C. Rubel is vice president of Union Oil Company, with whom he has been associated since 1923. A graduate of Purdue University and University of Arizona, Rubel began his business career with Commonwealth Petroleum Corporation, and later did work for Island Oil and Indiana Mexicana in Tampico Tamps, Mexico. He joined Union as assistant geologist, becoming petroleum engineer the next year. In 1929 he became chief petroleum engineer and assistant manager of field operations. He was named manager of field operations in 1931, director of production in 1936, and elected vice president in charge of production and exploration, January 1, 1939.

Everyone is familiar with the ordinary uses of petroleum such as fuels, lubricants, burning oils, greases, road oils and asphalts; and shortages of the last war dramatized such synthetic products as rubber, toluene for TNT, a few of the plastics, and artificial fibers such as nylon—but let's take stock of the extent to which this invasion into our everyday life has progressed.

A summary of only a few of the items could go something like this—

We awaken to the buzz of an electric clock probably in a plastic case and operated from power generated by oil or natural gas; our pajamas and robe are probably all or partially rayon or nylon; we use a plastic tooth brush with plastic bristles and paste compounded with detergents; the same for our shower and morning shave; we use a plastic curtain on the shower and linoleum on the floor—all of which are largely petroleum products.

We dress in shorts, socks, shirts, and ties, many of which are wholly or partly of synthetic fiber, and put on a suit probably containing varying percentages of such material.

We eat our breakfast cooked by natural gas, our bacon and eggs preserved in a refrigerator using a coolant made from petroleum. Our milk and many other products come in waxed containers and our morning paper is sized with paraffin and printed with inks compounded with oils and lampblack, both from petroleum.

If we might invade the intimacy of milady's boudoir, we find even a greater array of articles dependent upon petroleum.

Lingerie, hosiery, dresses, and slacks are largely of synthetic fibers. Face creams, lipstick, and many toilet lotions and perfumes contain petroleum derivitives to prevent them from becoming rancid or to provide a base.

What would a modern mother do

without the great array of plastic materials—from panties to wading pools—now available for baby's wear, feed- and amusement?

In the realm of the kitchen and laundry, washing powders, grease removers, and various cleaning fluids have practically displaced soap and are almost entirely of petroleum origin.

And if perchance it becomes advisable to bolster hubby's morale a bit, aspirin and several of the vitamins come from the same source.

Outside of our personal life our dependence is even greater; our plant foods, insecticides, and pest controls come largely from petroleum; our vegetables and grains are probably produced on mechanized farms powered with gasoline or diesel; our solvents for paints, varnishes, and lacquers; our endless array of plastics and resins; a host of industrial chemicals; therapeutics, new fibers, and explosives are all products of petroleum.

I pose as no authority on this phase of the industry, but I am told by our research and chemical experts, with an eager gleam in their eye, that the science of petrochemistry is just an infant in its development, and that future development will even more profoundly affect our everyday living.

The tremendous increase in the utilization of petroleum products is best reflected in the annual per capita consumption of all petroleum products, which has increased steadily from 3.6 bbl per person in 1920 to 16.8 bbl in 1952.

Adding to this figure the oil equivalent of the natural gas consumed would raise the per capita consumption for all petroleum products to the equivalent of 25.4 bbl.

The natural question, then, which must occur in our minds as we look to the future is—*have we an adequate and dependable supply of this essential material for the predictable future to maintain our expanding requirements?*

Although opinions on this subject are a matter of much controversy within the industry and among the many self-appointed experts outside of the industry, I would like to "go 'way out on a limb" as the saying goes, with the unequivocal statement that, *given a continued climate of free enterprise in which to work and a healthy industry to carry on, there is no reason for a shortage of petroleum products in the predictable future.* This is my thesis.

I am well aware that engineers want reasons and facts, not Pollyanna pronouncements. To substantiate a statement of this sort, I believe I can supply these reasons, if not the absolute facts.

I will do so by inventorying what I believe to be the potentially available sources:

In the first place, we have within our territorial boundaries an estimated proved producible reserve of approximately 30 billion barrels of liquid products and an estimated current rate of availability of 8,159,000 bbl per day, of which our current production is 7,204,000 bbl.

It is at this point that our statisticians usually mislead us by dividing the 7,204,000 bbl of daily production into 30 billion of reserve and coming up with a figure of 11.2 years indicated supply.

Such a figure is both meaningless and entirely confusing to the average person who naturally concludes that in 11.2 years we will be out of oil.

We are only interested in the rate of availability.

As a matter of fact, it will take many years, 30 to 50 perhaps, to produce the bulk of the 30 billion barrels, and we will still have a lot left.

The significant question is—where or better when does our indicated ability to produce fall below our estimated demand?

We cannot maintain our current rate of production for more than three years without the addition of new reserves, at which time the decline in our current productive sources will be rapid. A statistical extrapolation of our current producibility as compared to our estimated demand will show the curves crossing in 1955 and a large and increasing gap developing from that point on. Where will our new reserves come from?

At this point I must say that a pure statistical analysis and predictions based on such analysis always fail to give anything approaching a correct appraisal of future supply, as proved by the fact that statistically we have been running out of oil for the past 40 years to my knowledge, and yet today we have the largest reserve and the greatest daily production in our history.

The reason lies in the fact that there is no statistical way to apply to the formula the factors of resourcefulness, enterprise, and ability of the American oil producer to meet new demands and new conditions, yet these qualities have met the requirements of our country in the past and may be depended upon in a large way to meet those of the future.

Where then may we look for our future supply?

Potential U. S. Oil Sources

A simple inspection of the total area of possible productive territory in the United States, as compared to the areas of actual production, leaves little doubt that we are a long way from exhausting our opportunities for finding new oil fields. This is dramatically illustrated by the fact that the three most important discoveries in California during the past year were made in areas which had been actively explored since 1900.

The facts are that we have not run out of potential areas of new discovery, but that we have about run out of tools—and here again you, as mechanical engineers, may render us more valuable service.

A large part of our potentially favorable prospecting areas exists under geological conditions that cannot be determined by our present exploratory methods, but could be determined by drilling a lot of deep exploratory holes if such procedure could be accomplished at a price that would not make finding costs prohibitive.

You give us a drill which will go to 10,000 ft for from $2 to $2.50 per foot instead of the present $10 to $15, and I will predict an era of new discovery, which will surpass that following the application of the seismograph to oil field exploration in the early 30's.

Our requirements for such a hole are relatively simple. It need only be of sufficient diameter to permit the taking of cores and electric logs, say 4¾-in. at the bottom, and the machinery must be light and portable.

You give us the machinery and we will use it as an added exploratory tool to find the oil.

It is only fair to say that many oil tool manufacturers and many drilling companies are working on this problem and much has been accomplished, but there is still a long way to go to reach the goal mentioned.

It should also be stated that the best scientific brains in the country are at work improving our present exploratory tools, such as the seismograph, magnetometer and gravity meter, as well as developing other tools and techniques. Out of this work will undoubtedly come some better results than we are now getting.

In spite of these handicaps, we are making discoveries the hard way at a rate greater than that required to meet our expanding demand.

Tideland Possibilities

Congress has recently quitclaimed back to the states the oil rights within their respective traditional territorial limits and this, with the offshore area beyond, opens up a vast new potential supply, particularly along the coasts of Louisiana, Texas, and Southern California.

Estimates of recoverable reserves from this source are, of course, only indicative, and range from 5 to 25 billion barrels along the Gulf of Mexico and from 1½ to 5 billion in California. This will likewise pose the problem of the design of a structure for drilling wells in 100 to 300 ft of water—a worthy problem for the mechanical engineer with seagoing ideas.

Secondary Recovery

By our conventional production practice, we are only able to produce ultimately from 25 to 30 per cent of the oil in place our present fields. This is because we are largely dependent upon encroaching water and expanding gas within the reservoir to supply the energy necessary to transport the oil and gas from the reservoir to the well. We exhaust this energy long before we exhaust the oil in the reservoir.

Here then is a real challenge to our ability and one which industry is rapidly meeting by supplying supplemental energy to the reservoir by means of water or gas pumped back into the reservoir from the surface.

By this means, generally referred to

XUM

as "secondary recovery," yields of from 60 to 75 per cent of oil in place have been accomplished.

Assuming a national reserve of 30 billion, of which 60 per cent is amenable to secondary recovery, and assuming a 25 per cent normal recovery, we have available for secondary methods 30 X 60 X .75 = 13.5 billion barrels of oil in place available to secondary recovery methods. If 50 per cent of this can be recovered, 13.5 X .5 or 6.75 billion barrels will be added to our producible reserves.

Natural Gas

When considering crude oil, we must also consider natural gas and its associated liquid products.

Gas is produced in conjunction with the production of oil—in the form of gas distillate wells where the gas may contain from 10 to 100 bbl per million cubic feet in the form of a condensate, and as a "dry gas" substantially free of recoverable liquids.

Approximately 34 per cent of our national gas production comes from oil wells and the balance from gas distillate and dry gas wells.

Domestic gas reserves as of December 31, 1952, are estimated at 199.72 trillion cubic feet. At a Btu equivalent of 6,000,000 cu ft per barrel of crude, this equals 33 billion barrels, or more than the national proved oil reserves.

My remarks about possible new sources of oil apply as well to gas.

The industrial use of gas, particularly in public service power generation and general steam requirements, is the equivalent of many hundreds of millions of barrels of fuel oil annually, and hence frees that oil for conversion to other products.

Effect of Crude Prices

There is a definite relationship between price of crude and both current supply and reserves.

A substantial proportion of the nation's daily production comes from small wells of from 5 to 10 bbl per day output. As a matter of fact, the average production for the 447,978 producing wells reported in the country as of January 1, 1952, was only 13.7 bbl per day.

Many of these wells are at or close to the "marginal" class where the difference between the cost of production and the return is very small, leaving no surplus for repairs, cleanouts, or replacements, and forcing the premature abandonment of many wells annually which are still capable of producing thousands of more barrels of oil.

A crude price increase immediately provides more income to the producer and permits him to maintain his wells in producible condition, thereby increasing both the current and the ultimate production. An increase of only 2000 bbl per well in the ultimate production of all the wells in the country would add approximately one billion barrels of reserve.

Increased crude prices likewise stimulate exploration, which in turn results in more discoveries.

Historically this has always been the case; and as exploration becomes more costly, the relationship between crude price and exploration activities will be more critical.

Supplementary Sources of Supply

To augment our domestic supply, there are several foreign sources that are tributary to and dependent on us for a large portion of their market.

Venezuela, with an estimated proved reserve of 9.6 billion barrels and a current daily production of about 1,600,000 bbl, is the most important as a supplier of crude to our east coast and Gulf Coast ports.

During 1952, imports from this source averaged 325,000 bbl per day, but have increased to more than 1,000,000 bbl per day during the latter part of 1952 and 1953.

Venezuela has large potentialities, both for increasing reserves and for expanding daily production.

Canada, with its rapidly developing production, will shortly become an exporter of crude and natural gas. A crude line from Alberta to Vancouver is scheduled for completion during the latter part of this year. This line will have an ultimate capacity of 200,000 bbl per day and will supply much of the requirements of the Pacific Northwest, relieving California of that burden.

Additional surplus may become available for export through the existing line eastward.

Canada's current natural gas reserve is estimated by DeGolyer and MacNaughton, according to the published reports, at 11 to 18 trillion cubic feet. Because of the proximity to our own markets, surplus gas over and above Canadian needs is available to our own industry. A gas pipe line connecting the reserves of the Peace River area in Alberta with Vancouver, Seattle, and Portland has been approved by the Canadian authorities and is now under consideration by our own Federal Power Commission, whose approval will begin immediate construction on the line. This would bring an estimated 365,000,000 cu ft of gas per day into the area, and this amount would probably be substantially increased as industry takes advantage of this source of fuel.

With the possible exception of Mexico, whose gas reserves are not at the moment important, the natural gas from foreign countries will be of no direct benefit to our own economy except as it might be used locally as a substitute for liquid fuels that would then become available for export.

Kuwait, Bahrein, Saudi Arabia, Borneo, and the East Indies, with an aggregate developed reserve of 20 billions, are available to us as the competitive price permits.

Future developments along the west coast of South America and in Central America may add greatly to this total.

It must here be clearly emphasized that the degree to which these foreign oils become available to us is largely a matter of economics—as is indeed the development of our domestic sources.

THE AUTHOR climbs from bathysphere, one of the experimental devices which it was hoped might aid the oil search.

As exploration becomes more difficult it becomes more costly, and as oil is brought from foreign countries and longer distances, it too becomes more costly. When the demand comes, however, the supply is available although the consumer must pay the freight.

It should likewise be emphasized that the enjoyment of the benefits of oil from these foreign sources requires an integration of such production as a supplement and not as a substitute for our own.

This is both an economic and a political problem, with a preponderance of weight on the political. It will require some real statesmanship to so arrange such considerations as tariffs, trade relations, and monetary exchange as to insure the maximum benefit.

We see some of these problems in the present discussion between the large importing companies and the independent producers of West Texas over the present import of Venezuelan crude.

Synthetics

We are not wholly dependent upon crude from natural sources alone for our future supply. Within our territorial boundaries are potential sources of petroleum or their fuel equivalent in producible barrels many times the volume of our known national petroleum reserves and greater even than the known reserves of the entire world.

Probably the first major source of "synthetic" fuel will be the great deposits of oil shale in the Green River formations of northwestern Colorado, where it is estimated by the U. S. Bureau of Mines that more than 100 billion barrels of shale oil may be recovered.

Shale oil is not the same as crude petroleum, but with proper treatment, most of the common products of petroleum may be made from it. Cost of this conversion will be greater than that of refining natural crude, but this may be more than offset by the elimination of

"finding cost," which is a large and increasing factor in present production.

The actual cost of gasoline from oil shale delivered to Los Angeles has been the subject of much bitter debate, but probably the best estimate was made by the committee of the National Petroleum Council which, on the basis of a 200,000-bbl per day plant, placed the cost at 14.7 cents per gallon, allowing a 6 per cent return on invested capital. This compares to a current refinery price of approximately 12.7 cents. The margin is close, and I personally believe the time when gasoline and other products from this source will be used in West Coast markets is much less than generally estimated.

It also seems to me to be highly desirable to carry oil shale processing forward to the point of demonstrating the workability on a commercial scale. This would provide for relatively quick conversion to large scale production in the event of war.

Coals and Lignites

Synthetic liquid fuels can likewise be made from coal and lignite, and although by presently known means the cost of conversion is much higher than shale, the potential supply is great and may be utilized when needed. An interesting idea now under test is found in the experiments with burning coal in place.

Other Sources

There are relatively much smaller amounts of petroleum products to be recovered from tar sands situated in various portions of the western states, and although these in the aggregate probably do not exceed one billion barrels, they must be included in our inventory.

And last, but possibly not least, are the various alcohols to be derived from plant sources. It is not likely, from today's point of view, that these will become important as their use would involve competition with food production.

You may readily see from this formidable inventory that my thesis — "no scarcity faces us in the predictable future"—can be realized, but I hope you will see that it can only be realized under a free, competitive system where enterprise and resourcefulness may be rewarded in the traditional American manner.

It is also obvious that war, and particularly one that would menace or interfere seriously with the sea lanes, would greatly affect these plans and would undoubtedly cause at least temporary curtailment of non-essential uses.

I cannot let this opportunity pass without pointing out that you, as mechanical engineers responsible for the design of the machines that consume the bulk of these petroleum products, can make a major contribution toward insuring our future supply by cranking a little overall efficiency into your machines instead of going hog-wild on performance.

The automobile is, of course, the great offender.

Why is it necessary and who can legitimately make use of the performance built into our modern cars that permit us to go from a dead stop to 80 mph in a city block or do 150 mph on the highway?

Why must you continue the silly race for higher compression and higher octane values in the fuel required?

The increase in octane requirements for gasoline has mounted so rapidly with increasing compression ratios of the modern motors that it is having a very definite effect on both the volume and the cost of motor fuels.

The problem is a simple one of economics. By more complicated refining methods, higher yields can be obtained at higher costs. Likewise, higher quality can be obtained at higher costs, but in most instances at a sacrifice to volume. Let me hasten to add that the industry can and will provide this higher quality of gasoline as long as the customers demand it, but I want to emphasize also that the supply will become increasingly costly as the quality is improved.

We do not wish to be placed in the category of the very prominent motor car manufacturer who some years back persistently opposed the four-wheel brake. When he was finally driven to its adoption, however, full page ads appeared saying that the company still did not feel the four-wheel brake was necessary but that if anyone wanted it, they had the best four-wheel brake available in the industry.

Why don't you design a motor and a car that will perform within reasonable limits on just ordinary gasoline and sell such a car on the basis of overall economy instead of UNusable performance?

You would be making a real contribution to our future supply of motor fuel and to the financial problems of the motorist.

If you are building for the 500-mile race, that's fine; but it may interest you to know that these cars do not use gasoline at all, but various mixtures of alcohol and nitromethane.

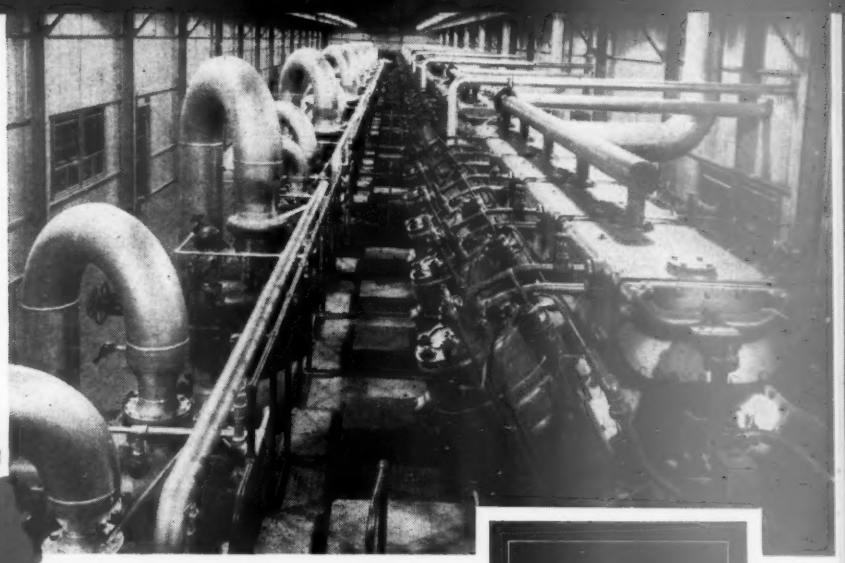
I cannot here, even though I were capable of so doing, make an exhaustive analysis of this very important subject; but I have, I believe, indicated to you more or less in inventory form the various sources, developed and potential, upon which we can depend for our future supply. I believe they are sufficient for the predictable future, when doubtless nuclear, solar, *photosynthetic*, or other forms of energy will share or take over the major portion of the load.

I hope that I have given you the reasons, and at least some of the important facts, to substantiate my thesis—"given a continued climate of free enterprise in which to work and a healthy industry to carry on, there is no reason for a shortage of petroleum products in the predictable future." * * *

RESEARCH points to future supplies. Through greater knowledge resources are used more efficiently and potential new sources of energy are developed.

IN THE LATEST SCURRY COUNTY PLANT

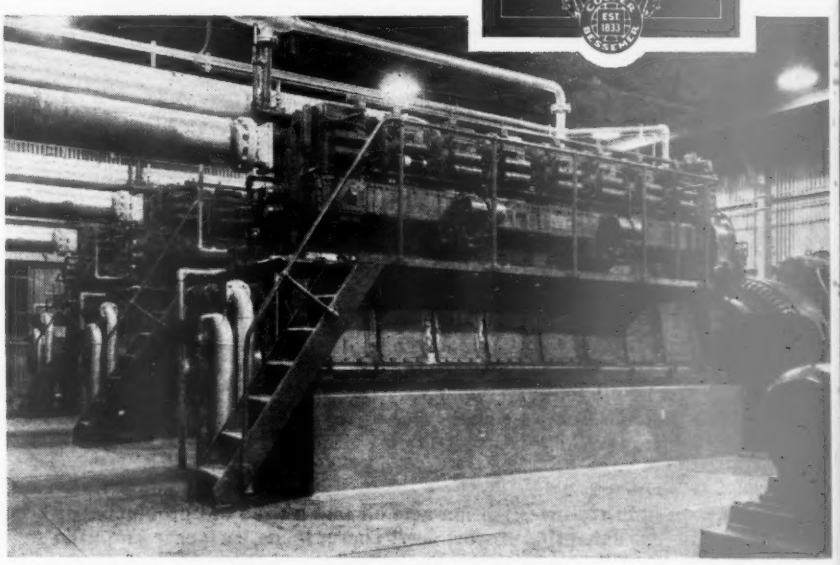
modern Cooper-Bessemers team up for a big 3-way job



This compressor line-up in the Fuller plant now consists of 880 hp GMV-8-TF units and 1100 hp GMV-10-TF units. Each unit is equipped with a high pressure cylinder for injection service.

These Cooper-Bessemer turboflow, spark-ignited four cycle gas engines drive 500 K.W. generators to provide electric power for the operation of all pumps, air compressors and similar equipment.

Another Example of Efficient Power at Lower Cost



GMV's *for processing and injection* JS's *for electric generation*

THE Fuller plant in Scurry County, Texas, operated by The Texas Company for the account of the Cogdell Field operator-owners, is one of the newest combination gasoline and pressure maintenance plants to go on stream. Designed and constructed by the O. L. Olsen Company, it has been winning high respect for its latest methods, modern facilities and efficient operation.

Here, as in so many other newsworthy plants, you'll find Cooper-Bessemer units at the heart of the operation. GMV compressors handling process and injection gas — JS gas engines driving 500 K.W. generators.

Check up. You'll find that your power needs, too, can best be met with modern Cooper-Bessemers.

The **Cooper-Bessemer** *Corporation*

MOUNT VERNON, OHIO — GROVE CITY, PENNA.

New York City Washington, D. C. Bradford, Pa. Parkersburg, W. Va.
San Francisco Houston, Dallas, Greggton, Pampa and Odessa, Texas
Seattle, Wash. Shreveport, La. St. Louis, Mo. Los Angeles, Calif.
Caracas, Venezuela Gloucester, Mass. Tulsa, Okla. New Orleans, La.

Same Plot--New Script

ERNESTINE ADAMS*

CONGRESSIONAL investigations may come as a bonus to the oil industry for tax paying over and above average. Or they may come because attacks on the oil industry have, in the past, earned votes for the attacker.

Whatever the cause, these frequent invitations to educate Congress and the public about the petroleum industry are valuable opportunities. How else could you possibly get 31 Congressmen to listen to the problems and operations of a diverse and complex industry and then get the whole proceeding in a reference book printed by the government?

In May of this year when oil companies belatedly acknowledged the obvious fact that they were liquidating their own businesses and advanced crude oil prices about 9 per cent, Congress almost let it pass.

After all price controls were off as the result of a convincing mandate from the electorate. Prices of other vital commodities, such as steel, had gone up without incident.

Then a New Jersey gasoline retailers' association official pressed for an investigation of price increases through a New Jersey Congressman, Charles A. Wolverton (R), chairman of the Commerce Committee and veteran investigator.

It was like waving a red flag at McCarthy.

Now don't get us wrong. We believe in investigations even when they have to be organized by some of those in the industry who cried "Do we want nationalism or individualism" when the Independent Petroleum Association of America went to Congress for a bill limiting imports.

It is not the Congressional investigations or their frequency we deplore. It's the quality of the performance.

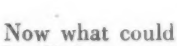
An oil industry investigation gets off like a tired old problem play in an exhausted repertoire. There is no suspense, no novelty, no dramatic surprise. The oil industry is the villain and is exposed in the first act and clearly labeled in the program. The investigating committee is the hero galloping to save the public whether the old homestead is mortgaged or the heroine is willing.

The day before the latest investigation was to begin Chairman Wolverton stated he had already concluded the price increases had nothing to do with competition and the free play of the market. In other words, the oil industry, says the head of the tribunal that is dragging the culprit before it, is a price fixer.

Now this is all right for a showboat run but pretty corny for the more sophisticated citizens. Especially since they've heard it before and the oil industry usually winds up looking more like the hired man than the mortgage forecloser.

There is no reason why we can't get more novelty and suspense in an investigation. Suppose the chairman of an investigating committee released this statement: "Some of my constituents think the oil industry didn't need to increase prices recently. We are not prepared to give an opinion about this right now but we've invited anybody who wants to explain the price rise to come before this committee and we intend to do our best to find out."

This is a standard come-on and would help insure followups in the newspapers and create more public interest in the whole proceedings. As it was this time, news of the investigation was dropped after the first day or so except in papers in the oil areas, whose people benefitted more directly from the price increase in more jobs, in larger equipment sales, and in state taxes from oil. These newspapers continued to record the attacks on the industry by those whom some readers referred to as "those Eastern Republicans" since the only ones named in the press were Wolverton of New Jersey and Heselton of Massachusetts.

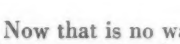


Now what could be done for a little dramatic surprise?

In all these investigations the spokesmen for the oil industry are well groomed, polite, patient and full of facts. They speak quietly and with authority but there is nothing to match the headlines made by the more dramatic politicians.

How about a change in the script? How about a rugged individual dressed like a driller who has just come off the tower who blows his top and yells at the committee something like this:

"We're giving you bargains! Gasoline is less in this inflated New-Fair Deal money even after the increase than it was in gold-backed money in the 1929 boom! It has higher octane than they even dreamed about then. If you can do better you shouldn't be in this room. You should be serving the public as an oilman and I should be here asking you how you do it and if you're stuffing your pockets in the process."



Now that is no way to talk to a legally elected representative of a congressional district and we don't really advocate it nor do we ever expect to hear it although we have a sneaking feeling it might go over with the public, which has itself become pretty overwhelmed with big government.

But the thing we should realize is the oil industry has worked its way up from its rough and erratic early days when an attack upon it was a vote-getter.

The public is beginning to learn that the gasoline it buys is about half taxes, partly paid by the industry and the rest collected directly for state and federal governments.

The oil industry itself has nearly two million workers, above average in skill and training, many of whom have invested their capital in the industry. Perhaps another two million are lease and royalty holders, and there may be another two million persons who are stockholders in oil companies. This is not a friendless industry nor is it an unfriendly industry.

The oil industry, like so many in this free enterprise economy, has not been alert in public relations but these are improving and they have a sound reason for improving—the industry has nothing to hide and much to be proud of.

We believe in investigations. We believe the Congress has a responsibility to investigate any action or lack of action that threatens the public welfare. We believe also that the oil industry has proved its ability to handle its operations with competence and has shown restraint in prices. We believe its economic problems should be judged *economically* and not *politically*.

But if eternal investigations is the price of freedom for the oil industry, then bring on the investigations. * * *

*Managing Editor.

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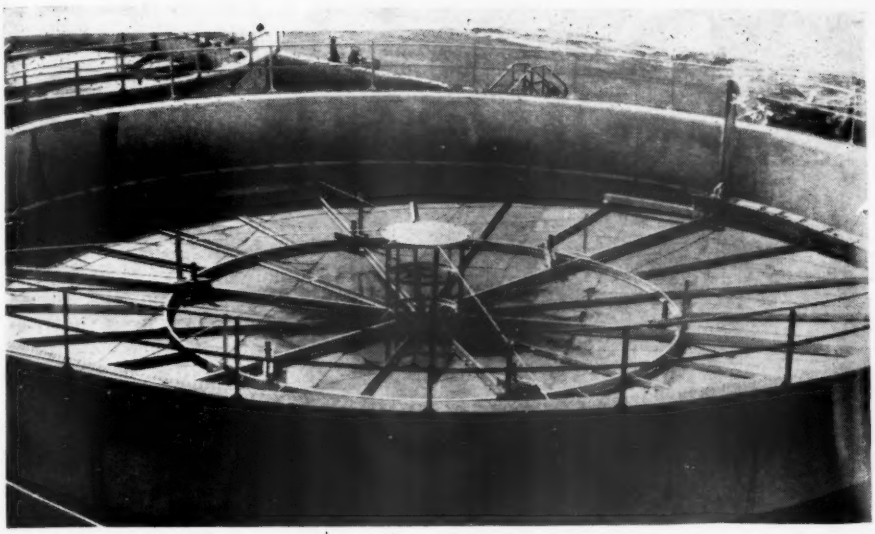
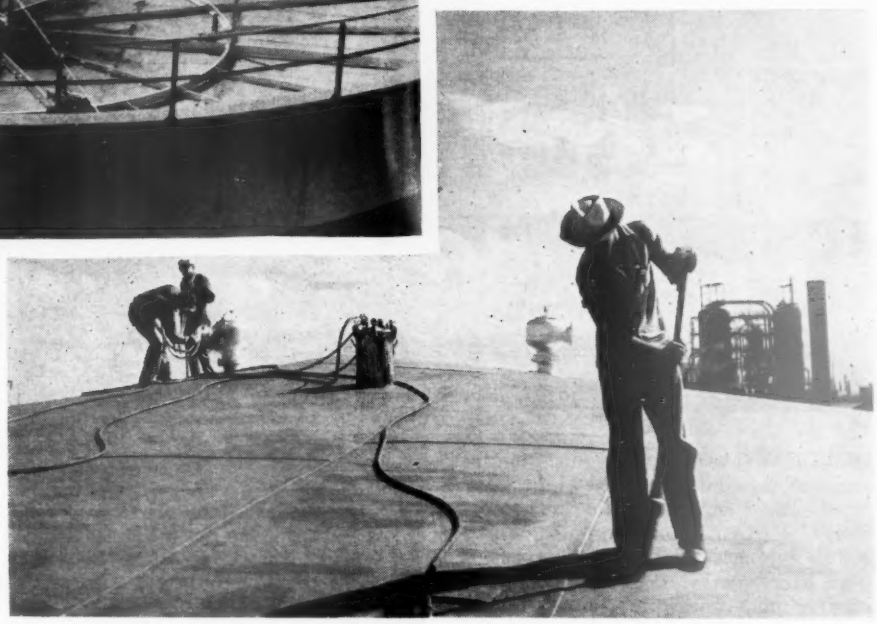


ALUMINUM has been used for many years for roofs of storage tanks for sour crude oil. At left is aluminum floating roof atop Standard Jersey, Bayway, New Jersey, refinery, storage tank. Tank, erected in 1932, was dismantled in 1940 to make way for new plant, and aluminum roof plates, in contact with oil surface, showed no signs of pitting. Aluminum roofs are in wide use in sour lake areas of West Texas.

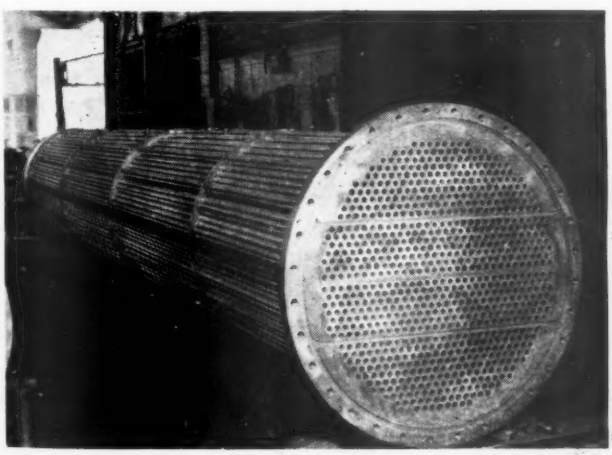


PAINTERS at right spray aluminum paint on Humble Oil Baytown, Texas, storage tanks. By reflecting a large part of the sun's heat, the paint aids in maintaining appreciably lower temperatures in the tank. Aluminum paint imparts protective and reflective properties to other materials. Paint is not darkened by hydrogen sulfide and provides protection to steel structures. It is also used for "dressing up" equipment. Durability is result of two actions of aluminum flakes: They act as reinforcements within dry film, and tend to float and become parallel with surface.

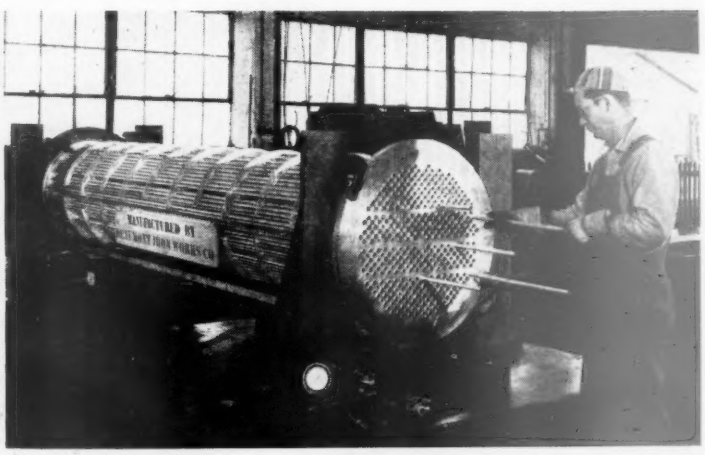
Petroleum Industry Finds Many Uses for Aluminum

FLOYD A. LEWIS

The Aluminum Association

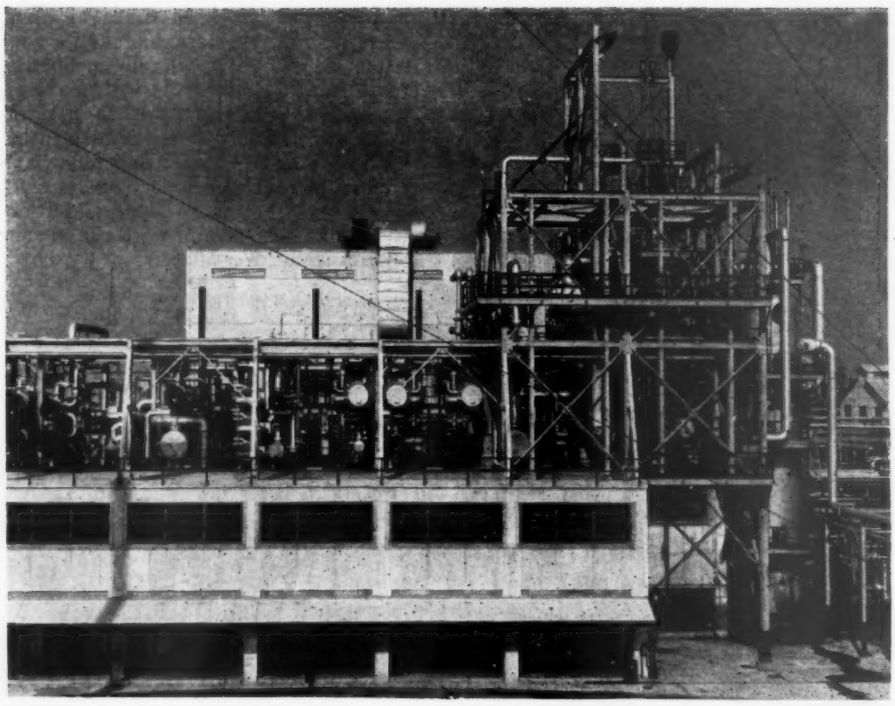


OIL to oil heat exchanger bundle with Aluminum 3S-H14 alloy tubes is found at Skelly Oil's, Tulsa, Oklahoma, plant. Aluminum is used in many refineries because of its good heat conductivity together with its resistance to corrosion.

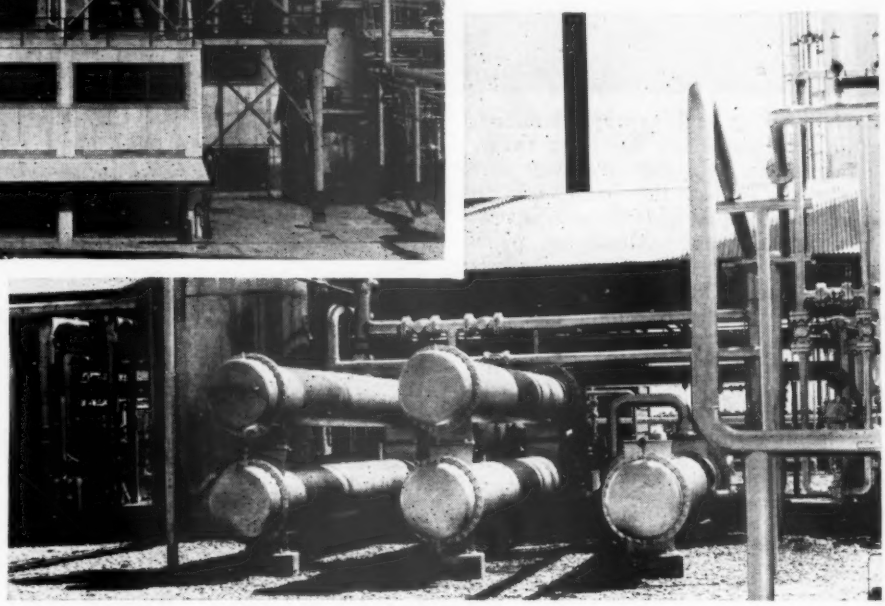


ALUMINUM TUBES are used for exchangers in gasoline plant service. Bundle above is constructed entirely of aluminum.

Many miles of tubing are used as instrument lines to transmit liquid or gas pressures from process equipment to control panels.



METHYL ETHYL KETONE plant at Baton Rouge, Louisiana, Esso Standard Oil refinery. Heat exchangers comprise a substantial portion of such plants and many of these are made of aluminum. Other typical applications include exchangers for condensing gasoline, naphtha, gas oil, etc., for propane chilling, and for compressor inter- and aftercooling. One refinery reported savings in maintenance of a heat exchanger by using aluminum tubes to handle furfural and furfural raffinates. Another used aluminum tubes in a heat exchanger handling separated water phase from catalytic cracking in which ammonia and hydrogen sulfide are present.



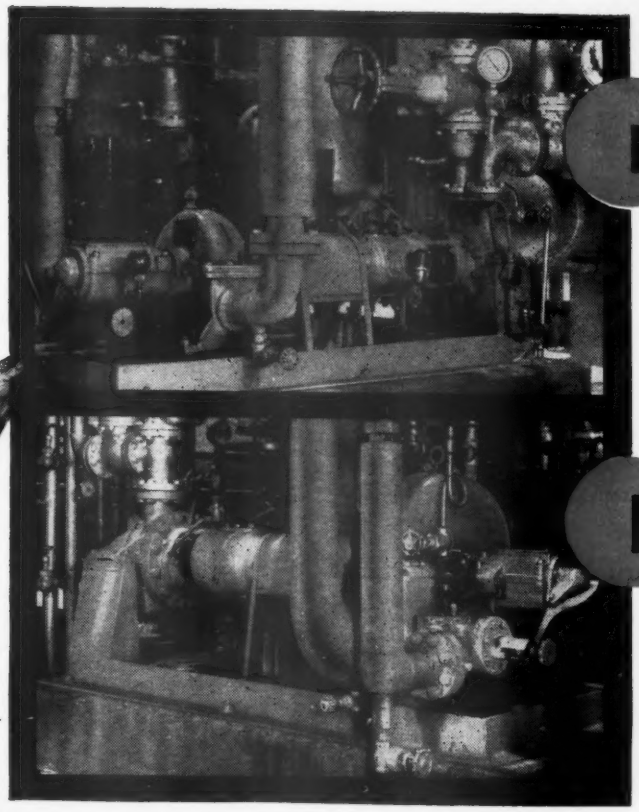
HEAT EXCHANGERS and tube bundles made of aluminum are used in the Lone Star Gas Company plant at Tyler, Texas, at right. Aluminum fin stock and copper tubing are used in many types of heat exchangers, and development of all-aluminum units is being rapidly pushed with improved aluminum brazing techniques that overcome many problems of joining. Aluminum tubing may be rolled into steel or aluminum tube sheets with standard equipment.

TREND toward aluminum has been found in office buildings as well as plants. The 13-story building built by General Petroleum Corporation in Los Angeles, left, has 59 vertical aluminum fins on three sides of the building shading some 16,000 windows. This screens out solar radiation greatly reducing the air-conditioning load.

Aluminum roofs reflect a high proportion of the sun's rays, keeping the interiors of buildings, tanks, or other structures roofed with this material cooler in hot weather. Advantages of using this nonsparking equipment in plants handling combustible materials may be readily seen.

Aluminum is one of the easiest metals to fabricate into the desired form. Large varieties of shapes, plates, extruded sections, and tubing are available in the many alloys, and these can be shaped and formed with ordinary metal-working equipment. Structures may be assembled by riveting and gas or electric welding.

Also of special interest to the petroleum industry is aluminum's resistance to sulfur compounds, carbon dioxide, refinery atmospheres, sea-coast environments, and cooling waters. Alloys of the clad types in which the cladding is anodic to the core, are particularly resistant to corrosion by most waters.



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1,000 H.P. is available for this process pumping operation (same plant as above). Dean Hill is on the job with this powerful steam turbine.

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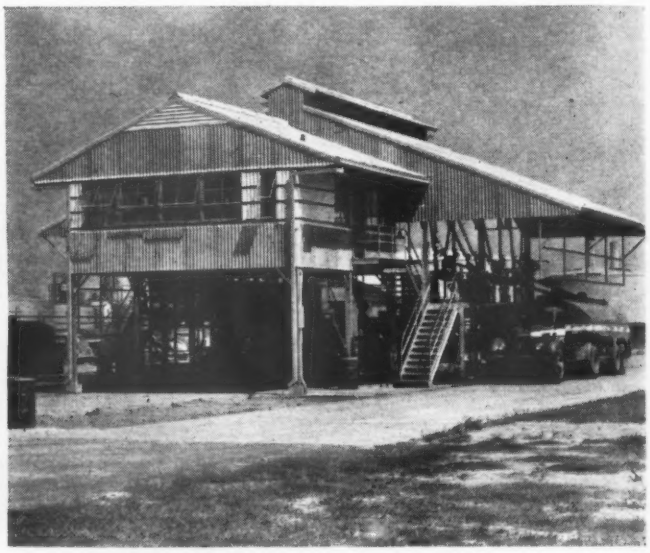
WORKMEN at Childers Manufacturing Company, Houston, Texas, fabricate material, and users, left, apply aluminum foil covering over pipe insulation. It is held in place by weather resistant plastic tape. In the form of foil, aluminum is used for insulation on tanks and tank cars, where high reflectivity of the aluminum surface results in lower temperatures in the interiors and reduces evaporation.

Sucker rods for well pumping have also been made of aluminum. Although these sucker rods are lighter, experience in this application has been insufficient to provide an economic or service comparison.

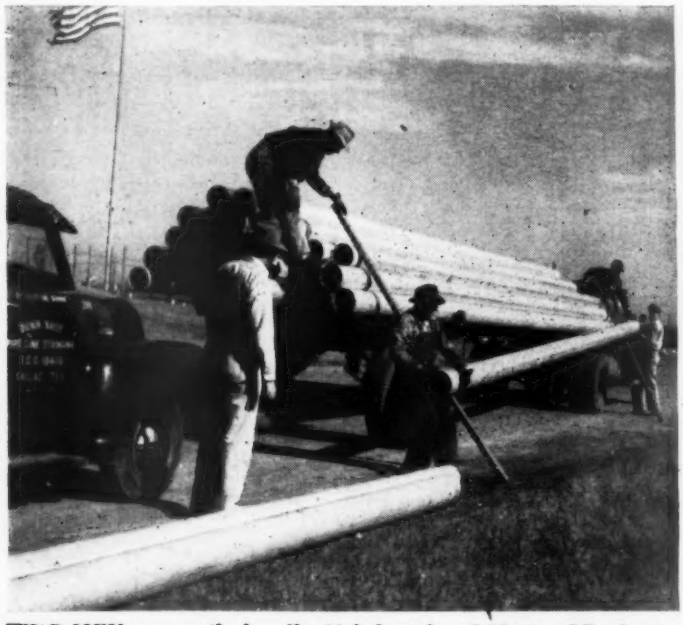
PIPE LINES of aluminum are particularly attractive for construction across rivers, swamps, and hilly terrain, where ease of handling and supporting offer advantages over other materials. Low-pressure gas gathering systems of aluminum pipe with modified wall thickness are now being installed in West Texas. This pipe affords extremely high corrosion resistance to the hydrogen sulfide present. A 100-ft string of aluminum shot-hole casing weighs about 60 lb—an important feature as an increasing amount of this casing is being transported by helicopter.

Aluminum pipe lines are also used for crossing rivers and swamps.

SEISMOGRAPH party in vicinity of Huntsville, Texas. Portable rig truck moving to next location where shothole was drilled. Much special equipment is being designed in aluminum for lightweight and is of particular importance for swamp buggies, portable drills, test rigs, and similar equipment.

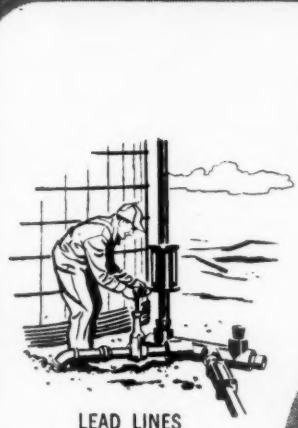


LOADING RACK for bulk petroleum products at Esso Standard Baton Rouge refinery. In line with general trend toward more of the lightweight metal in buildings of all types, the oil industry is also using a great deal of the metal in structures where no unusual exposure conditions are involved.

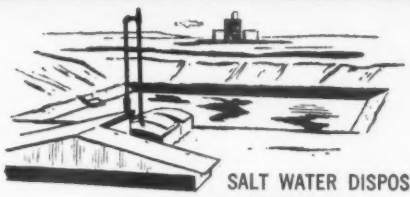


TWO MEN can easily handle 40-ft lengths of 8⅝-in. OD aluminum pipe. A number of test installations of buried aluminum pipe line have been made, most of them without external protection. They have shown good resistance to soil corrosion.

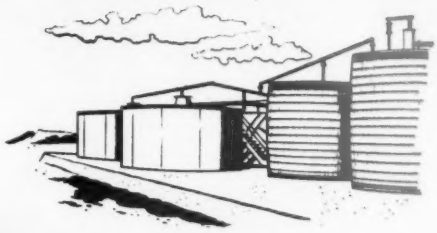
SMALL SUPPORTING SYSTEM and easy installation is permitted in crossing a river with aluminum pipe. Above, as each new length of pipe was welded onto end of preceding section, pipe was pushed ahead 30 ft onto cable suspension system.



LEAD LINES



SALT WATER DISPOSAL



GATHERING LINES

CONTACT

Carlon*

DIRECT

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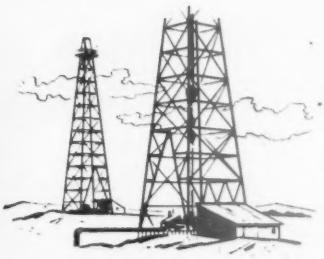
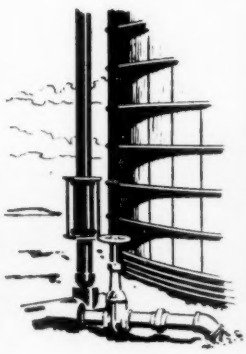
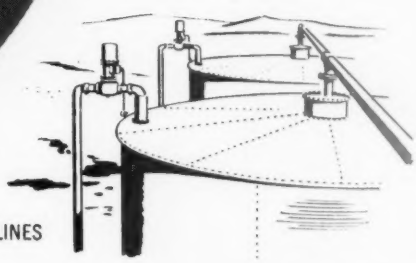


FRESH WATER LINES



RISERS



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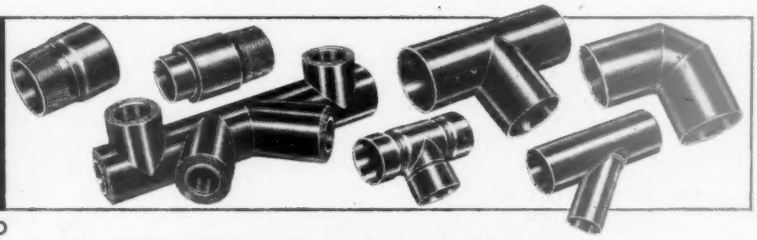
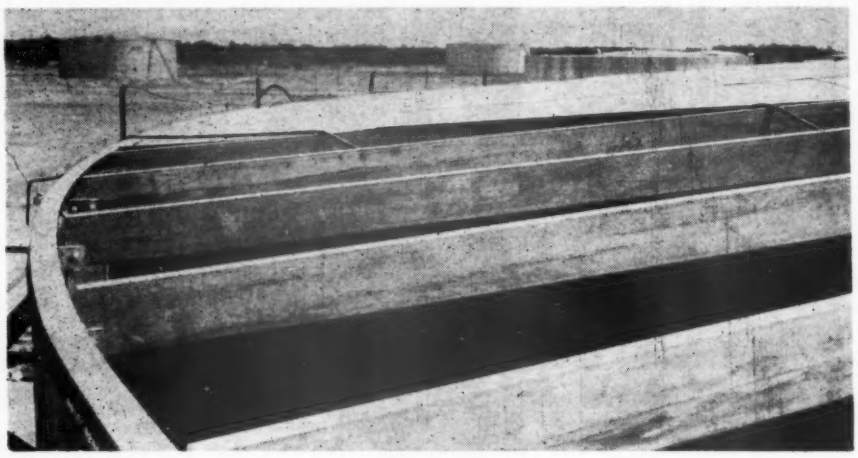


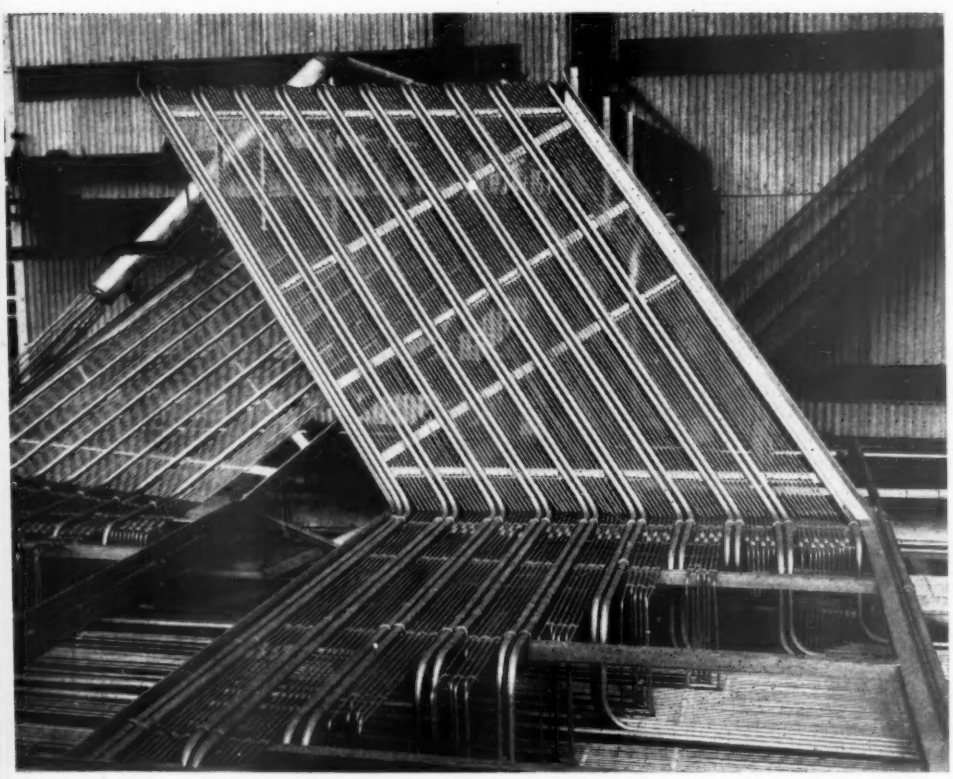
10555 MEECH AVENUE • CLEVELAND 5, OHIO
CARLON plastic pipe is produced in Texas, Colorado, Ohio, Oregon, North Carolina and Acton, Ontario, Canada.

TANK CARS of aluminum are used to transport many petroleum products. Here a finished tank is being set on underframe for fitting to wood cradle blocks. Tanks in sour crude areas are also being constructed with internal supporting structure, hatches, vent lines, and other fittings of aluminum.

ALUMINUM HATS are being used extensively in some areas by men working around rigs, as seen at the Shell rig, Gaines County, Texas, above. Hats are both light weight and serve as a protection from falling objects. Hats may be worn for year-round protection.

PETROLEUM STORAGE tank roof under construction by Gulf Pipe Line Corporation at Sour Lake, Texas. Tank has a diameter of 114 ft. Aluminum has been used for roofs of storage tanks for sour crude oil where steel roofs failed in less than 5 years. Some of the aluminum roofs have been in use for more than 20 years. Aluminum bubble caps have shown service life of 10 to 15 years with both sweet and sour stocks. Most important characteristics in this field are light weight and high resistance to corrosion combined with strength and high thermal conductivity. Effects of light weight extend beyond number of pounds for they enter into costs of shipping the material and of labor for construction.





RHB BUTYL control house at Humble Oil's Baytown, refinery. Control lines on roof leading from panel instruments to various units of the plant are made from aluminum tubing in many installations.

PRECAUTIONS in the use of this metal have been pointed out. Aluminum alloys, like those of other common metals, are subject to attack in the presence of mercury compounds. Care must be taken against introduction of mercury or its salts into process streams that will contact aluminium.

Contact between aluminum and most dissimilar metals should be strictly avoided in the presence of an electrolyte, because severe corrosion by galvanic action may follow. Aluminum may be protected by insertion of insulating sleeves or gaskets, and by painting with nonconductive paint or by wrapping with an insulating tape. Aluminum is not attacked by dry steam at temperatures below 400 F, but wet steams containing boiling water that has been carried over may be corrosive. Suitable traps may be installed to prevent water from reaching any aluminum equipment.

Users may save time and money and often avoid serious difficulties by drawing on producers, ASTM, TEMA, API, and ASME for best alloys for a given application. ★ ★ ★

The answer to high pressure gas scrubbing

The Problem

Cleaning waste liquids and solids from gas for pressurized reinjection into wells.

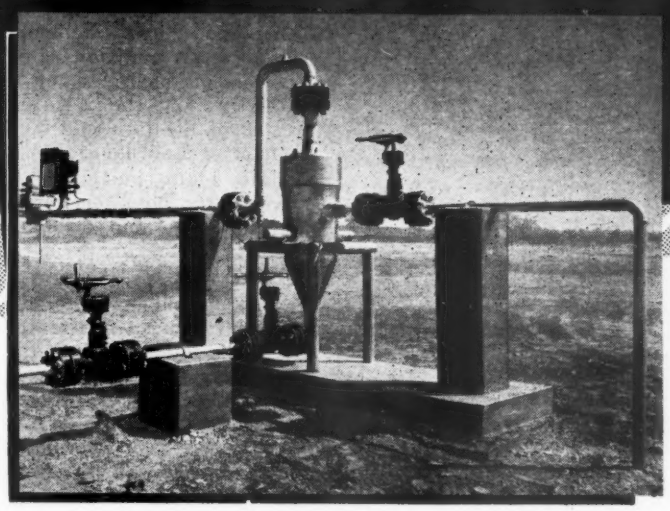
The Equipment

AEROTEC

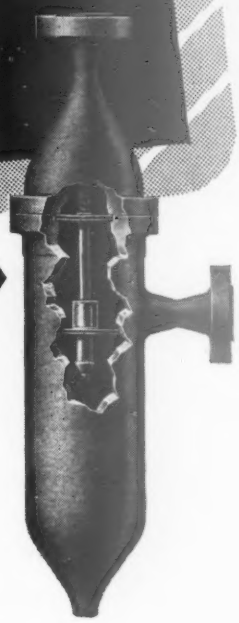
DRY GAS SCRUBBERS

The Results

1600 gallons of waste products extracted daily from 9 million cubic feet of reinjection gas.



Installations of Aerotec Gas Scrubber at University, Block 31, Field, Crane County, Texas.



Cutaway section of Aerotec Gas Scrubber designed for high pressure applications.

New Proof of the practical, profitable advantages of Aerotec Dry Gas Scrubbers comes from the oil-producing industry. This backs up the long experience of natural gas companies with hundreds of units in daily use. These Aerotec Scrubbers, at wells and in pipelines, are cleaning foreign liquids and solids from natural gas with exceptionally high efficiency.

This Aerotec high pressure application is successfully employed by the Atlantic Refining Company in a jointly-owned claim in the University, Block 31, Field located in Crane County, Texas. The Aerotec Gas Scrubber removes components of lubricating oil from gas going to injection wells at 4,000 psi. It has also removed sand, mill scale and iron sulfides, and because no fluids are used in the separation process, no residue is carried over to the gas.

Additional units are now being installed before new injection wells are put into operation.

Lightweight and compact, Aerotec Gas Scrubbers are easy to install. Available in standard units up to 100,000,000 SCFD, they can be manifolded to meet larger requirements. For experienced engineering assistance in matching Aerotec Scrubbers to *your* specific need, or for catalog data on these units, call or write The Thermix Corporation.

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GREENWICH, CONN.

Petroleum Profile

JOSEPH L. SEGER

President, Interstate Oil Pipe Line Company

FACED with the need to identify his company affiliation in some local bank or store, Joseph L. Seger would probably say, "I work at Interstate Oil Pipe Line Company." He is a modest, unassuming man who is disinclined to call attention to his position in the company, or in the community.

Coupled with this natural modesty is a sincere appreciation of the people whose activities he directs. He recognizes them as indivdual personalities, and respects their emotions, feelings, pride, and all the other sensitive traits possessed by human beings.

An employee, author of some special report or memorandum for "the boss," may answer his ringing phone to hear a cordial voice saying, "Bill this is Joe Seger. I want to thank you for the very fine job you did on that safety report."

This cordiality is spontaneous. It flows naturally from a spirit motivated by a sincere interest in the welfare of other people. Nor is he satisfied merely with his own efforts to know his people better. He urges his official and supervisory family to do likewise.

Recently, at a meeting of all top-level supervisors of his company, Joe Seger declared: "A supervisor—any supervisor—has no more important responsibility than that of having a friendly, open, face-to-face conversational visit with each man he supervises."

Because of his warm and friendly personality, Joe Seger possesses the ability to work with and through people, to get the job done satisfactorily. This ability is of great service to his company, to the community in which he lives, and to the oil industry in general.

The people of Interstate learned to appreciate Joe Seger more fully during the days of adjustment following the 1951 consolidation of the company's Tulsa, Oklahoma, and Shreveport, Louisiana, offices, and the resulting transfer of some 100 general office employees to the latter city. The announcement of the consolidation was made by him personally, in a series of employee meetings. It was made by him as a fellow employee, with a wife, three children and a home . . . a man who would face the same problems as the rest of the group.

After the consolidation, and after the old and new Shreveport employees had become fairly well settled in the completely remodeled office building, "the boss" decide something was lacking. He invited two people to visit him: President of the office employees' union and the assistant manager of the material department. The result was a handsome air-conditioned lounge in the basement featuring free coffee, tea, and hot chocolate for the employees. It was designed and carried out by a joint management-employee committee working at the personal invitation of President Seger to make it "something we can all be proud of . . . and enjoy."

Joe Seger's new home community was quick to learn of the newcomer's attitude and abilities. Soon after the 1951 move, he was elected a director of the Shreveport Community fund, and just recently was made second vice president. When the new Schumpert Memorial Hospital campaign came along, he was named chairman of the Special Gifts Division. He has also become a trustee of the Public Affairs Research Council of Louisiana.

Here again, in the field of public service, "the boss" encourages his employees to go and do likewise . . . encouraging by example as well as by word.

In the oil industry, Joe Seger's ability is reflected in a long record of service in various industry committees and organizations. He is a member of the American Petroleum Institute. He is on the board of directors of the Transportation Association of America. Formerly secretary of the Committee for Pipe Line Companies, he is currently serving as chairman of this group.

In all of his community and industry activities, Joe Seger's attitude or purpose is one of service rather than mere membership. His main personal rule in such matters is to accept responsibility only if he has time to do the job and do it right.

To do the job, and do it right, he can draw from a variety of training and experience. A native of Lebanon, Illinois, and later a school-time resident of Tulsa, Oklahoma, he earned a BS degree in business administration at the University of Illinois in 1927. In 1929 he was graduated from Yale University Law School. After four years in law practice in Tulsa he was employed in the legal department of The Carter Oil Company, and in 1944 was elected secretary of that company.

He transferred to Interstate as general counsel on June 1, 1946, and in December of the same year assumed additional duties as vice president and a director. His election to the presidency came on July 1, 1951, after several months as executive vice president.

But the real key to his doing the job, and doing it right, is the personal warmth and sympathetic understanding which he uses, instead of his title, to get a number of individuals to work together as a team . . . smooth, willing, and efficient. Personal modesty and sincere consideration for others . . . those are the tools "the man who works at Interstate" works with.

Presenting—

A NEW DESSICANT FOR DRYING NATURAL GAS

Field-tested at the Reddell Station of the Continental Oil Company, much promise is shown by this new dessicant, activated alumina. Comparison of its efficiency with that of a better known and accepted product in the opposing towers of a twin tower gas dehydration unit was made at stated intervals during the run.

After 20 months of operation, the alumina was still capable of adsorbing 12½ per cent of its weight in water before the dried gas water content reached the permissable limit of 7 lb of water per 1,000,000 cu ft, while the competing dessicant was able to adsorb only 7 per cent. Both dessicants had the same approximate capacity at the start of the tests. The activated alumina also stood up well physically in the test, its particle break-down and decrease in crushing strength being comparatively minor. Complete descriptions of the tests are given together with a brief outline of the operating principles of the twin tower gas dehydration unit.

THE CALIBRATION OF GAMMA RAY LOGS

Although they have been used for many years as a valuable tool in the art of drilling and completing wells, the main value of the gamma ray log in the past has been for accurate correlation. We now are offered a new concept in the use of this tool—that of porosity determination of shaly sand zones when used in conjunction with the neutron log. While the value of this latter log has long been recognized in clean sand horizons, it will react to shale in shaly sands and to estimate correctly the effective porosity, it is necessary to correct the neutron deflections for the amount of shale present in the formation. Assuming a fixed relation between the amount of shale in a formation and its radioactivity (this assumption will hold true in formations of a given age within an area) the gamma ray log should provide a source of data for this correction.

This paper describes the calibration of the gamma ray logs in terms of actual formation radioactivities. The method by which this calibration is carried out is described and departure curves are presented which permit correction for the adsorption due to mud, casing, and cement in the borehole. Application of the corrected data so obtained will be suggested in an article to follow.

AUTOMATIC CONTROL EQUIPMENT FOR OILFIELD INSTALLATIONS

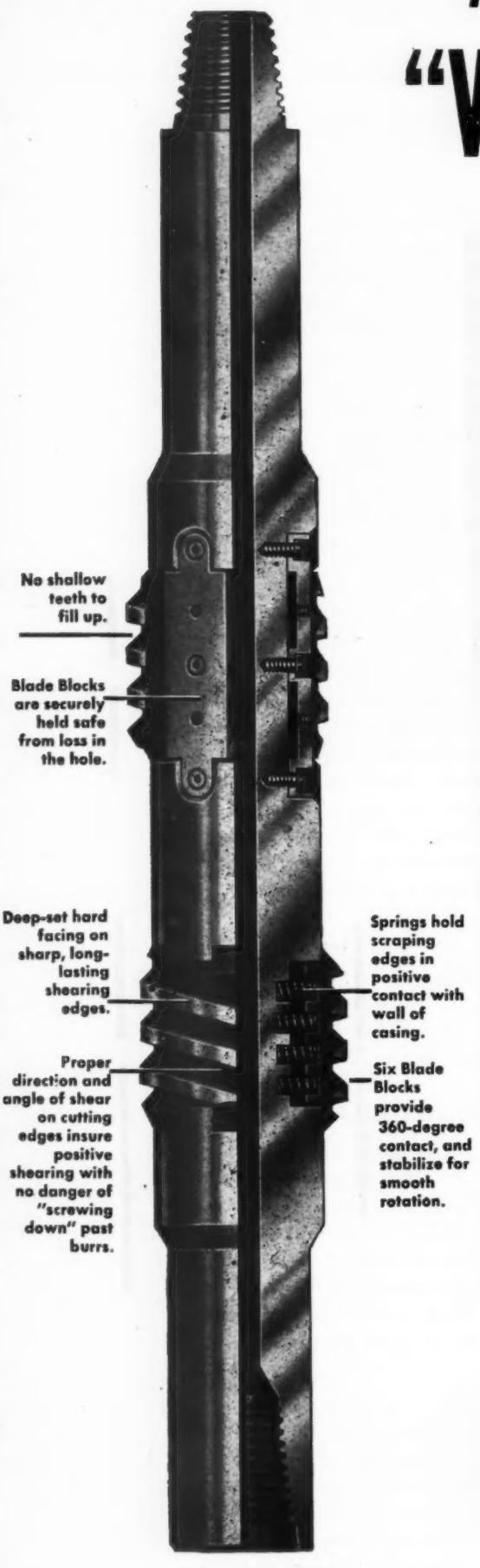
Through the proper selection of control equipment, operators may assure the adequate automatic action of the controlled subject with a minimum investment. Two rough groupings of automatic controls, starting and stopping devices and protective devices, are described in the paper and suggestions as to their application are made. The author points out in detail how the cost of control installations may be held at a low level, showing that there are almost always more than one control for a job but that the various controls offered will have varied capabilities and the least expensive one will frequently suffice for the desired purpose.

EMULSION ZONE PRODUCTION

Recovery of substantially large reserves from the Pariñas sand in the La Brea-Pariñas Concession in Peru is promised by well completions in the so called "Emulsion Zone." Recognition of this reserve occurred early in the productive life of the field. It has been only recently, however, that an effort has been made to produce the zone. The authors point out the problems attendant to the completion of the wells and note that the maintenance of reservoir pressure appears to play a large part in the successful production of the horizon. An explanation for the occurrence of the oil and water in the same zone is offered.

XUM

How is the
"Working Surface" of


No shallow teeth to fill up.
Blade Blocks are securely held safe from loss in the hole.
Deep-set hard facing on sharp, long-lasting shearing edges.
Springs hold scraping edges in positive contact with wall of casing.
Proper direction and angle of shear on cutting edges insure positive shearing with no danger of "screwing down" past burrs.
Six Blade Blocks provide 360-degree contact, and stabilize for smooth rotation.

Baker Model "C"
ROTO-VERT Casing Scraper
Product No. 620-C

Unless the inside of your casing—the vital "working surface"—is clean and smooth, there is always a possibility of trouble in future operations. Burrs from gun-shot perforations, hardened cement or mud, and even mill scale are all dangerous when the time comes to run testers or swabs, or to set cement retainers or packers of any description.

The Baker Model "C" ROTO-VERT Casing Scraper removes all obstructions from the inside of the casing, leaving it clean and smooth. Burrs or imbedded bullets are sheared away; cement, mud and scale are scraped away, so that any down-hole work can be safely done at once, or during the years to come.

SCRAPE WHILE DRILLING OUT

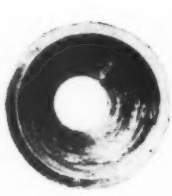
The ideal time to use the ROTO-VERT Casing Scraper is during the drilling out of cement, at which time it is run as a "follow-up" behind the bit. Thus in a single run you can also remove all hardened cement, mud, burrs and scale which might *later* damage swabs or testers, and cause packers or retainers to set prematurely—or never set at all.

EASY TO RUN—LOW-COST RENTAL

The Baker ROTO-VERT Casing Scraper is simple to run, and will effectively clean the inside of the casing when either reciprocated or rotated.

No service man is required, and the low rental cost is paid for many times over by freedom from future damage to bailers, swab rubbers and packers, as well as by the elimination of future delays and re-running expense.

SEE HOW THIS BURR . . . ripped this packing element,



and how ROTO-VERT could have prevented the damage by shearing away the burr.

# of your casing?

WHY **THE ROTO-VERT IS SAFE AND SIMPLE TO USE AND COSTS LITTLE TO RUN**

This helix-blade-type scraper can be either "spudded" (reciprocated vertically) or rotated for the removal of gun-perforation burrs, imbedded bullets, cement sheath or other obstructions from the inside of the casing.

The body is machined from bar stock, with two sets—a total of six—rugged Blade Blocks positioned for overlapping, 360-degree scraping coverage. The most outstanding feature of the Blade Blocks is the direction and angle of shear of the scraping edges. The slant of these scraping surfaces is in a direction OPPOSITE from that encountered on other helix-blade-type casing scrapers, and the shearing edge is set at a smaller angle from the horizontal. These features result in the fact that the ROTO-VERT will not "screw" down past burrs as it is being rotated. And when it comes to removing cement sheath or other casing coatings, you are assured of actually removing the material with the ROTO-VERT, instead of merely cutting threads in it.

REMOVING PERFORATION BURRS AND BULLETS

On rotary rigs best results are obtained by first running the ROTO-VERT Scraper *completely through* the perforated section WITHOUT ROTATION. This initial run will either shear or knock off the majority of imbedded or projecting bullets, and shear away most of the ragged perforation burrs. Then pull back the ROTO-VERT Scraper and rotate it through the perforated section. This second run permits the helix scraping edges to shear to their fullest extent, leaving perforation holes practically flush with the casing I.D., and the entire perforated section clean and restored to gauge.

When running the ROTO-VERT on tubing, or on a wire line (with suitable sinker bars and jars) it is merely run through the perforated section, then pulled back and run through again. If the ROTO-VERT runs through the perforated section smoothly (as indicated by checking the weight indicator) complete burr and bullet removal is a certainty.

REMOVING CEMENT SHEATH, HARDENED MUD OR SCALE

Recommended procedure is to install the ROTO-VERT just above the bit when drilling out cement, to remove the thin sheath of cement always left, even though a maximum gauge bit is being used. Hardened mud, cement, paraffin, or mill scale are completely removed in a single run.

On old wells (or when rotary equipment is not present) the ROTO-VERT, run on tubing, will successfully remove various casing coatings WITHOUT ROTATION. A spudding action usually quickly clears up any rough or stubborn "tight spots."

A modified ROTO-VERT can be furnished to operate with equal success when run on a wire line equipped with sinker bars and jars.

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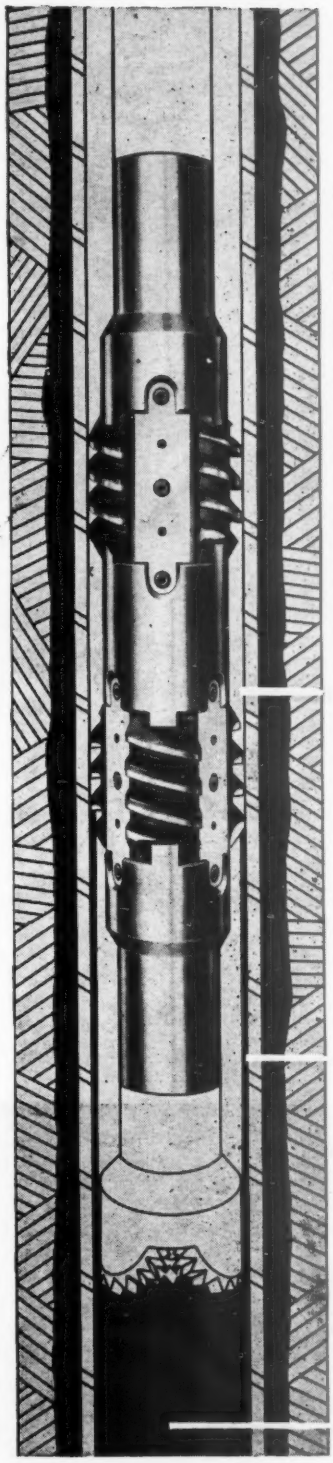

Even when a maximum gauge bit is used for drilling-out, a thin sheath of hardened cement remains to interfere with future operations. To visualize how ROTO-VERT removes this sheath, see left.

All cement, scale, burrs, etc., have been removed by the ROTO-VERT Scraper, and the vital "working surface" of casing is left clean and smooth.

This thin sheath of hardened cement always remains after the bit has passed.

Cement to be drilled out.

Cross-section of casing showing gun-perforation burr, before scraping...

and after ROTO-VERT was run.

This brittle cement sheath prevents the slips of pack-off tools from gripping the casing.

...Here is cut section of the same casing showing how slips tried, *unsuccessfully*, to set against the cement sheath.

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REED twin blast ROCK BITS

Slush from the nozzles of **REED** Twin-Blast Rock Bits blasts against the bottom of the hole and sweeps across at high velocity — carrying cuttings up into the return mud stream immediately so cutter teeth can work on new formation.

The result of this efficient bottom hole cleaning action is faster drilling, more hole per bit, fewer round trips and lower drilling costs.

4194

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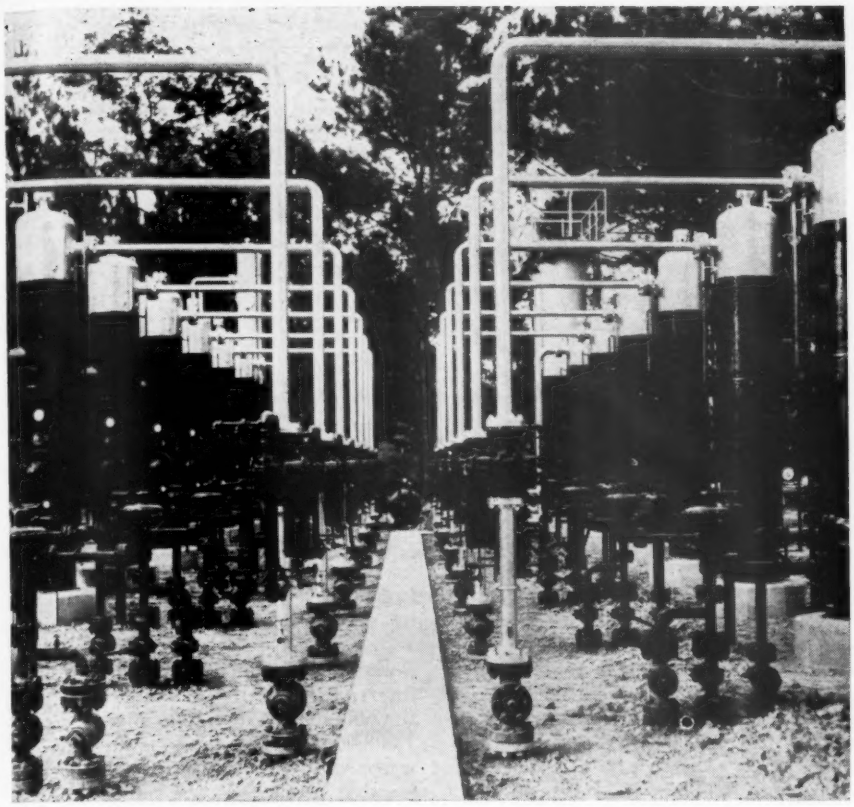


Continental Oil Company's Reddell central separator battery, site of dehydration test, Reddell, Louisiana.

A New Desiccant for Drying Natural Gas†

Results of field test on dehydration of high pressure natural gas using a new type activated alumina

ROBERT J. GETTY[1], C. E. LAMB[2], and WAYNE C. MONTGOMERY[3]

A new and improved desiccant demonstrating superior drying capacity and physical properties—Activated Alumina H-151 — is introduced. Results of the first 20 months of a full scale field test, conducted at the Reddell separator station of Continental Oil Company, Reddell, Louisiana, are reported. In this test, Activated Alumina H-151 was compared with the competing desiccant in a twin-tower dehydration unit for the dehydration of high pressure natural gas. After twenty months of operation, the activated alumina is still capable of adsorbing 12.5 per cent water, while the capacity of the competitive gel tested is approximately 7.0 per cent. Both desiccants had approximately the same capacity when the test was begun. The Activated Alumina H-151 has also stood up well physically in this test; its particle breakdown and decrease in crushing strength was minor compared to that of the competing gel desiccant tested.

PRODUCERS of natural gas have for years recognized the importance of dehydrating the gas before transmission in pipe lines. This removal of water is necessary both to prevent corrosion in the pipe lines and equipment, and to prevent "plug-ups." These latter are caused by the formation of ice-like hydrates, which, at the high pressures involved, can occur well above the normal freezing temperature at atmospheric pressure. Such a "plug-up" usually causes the stoppage or diversion of the gas stream until the ice is melted or blown out of the line. Wet gas is therefore an expensive proposition.

One of the most common methods of removing water from a fluid stream is by the use of a solid desiccant contained in a drying tower. There are many designs of such drying towers available but the principles of operation are similar. In any of these towers, the wet gas enters a bed of solid desiccant of sufficient depth to remove the water in the gas by contact adsorption. Dry gas emerges from the effluent end of the desiccant bed for varying periods of time. The time of operation depends on several factors, such as, temperature, gas velocity, water content of gas, moisture holding capacity of the desiccant and depth of desiccant bed. The water adsorption has been shown to occur in a so-called "zone of adsorption", which moves progressively through the bed. When this zone reaches the exit end of the bed, the moisture content of the effluent gas begins a fairly rapid rise. This point has been labeled the "break-point". Within a fairly short time after the "break-point", it is necessary to divert the gas flow to another tower containing freshly activated desiccant. After the removal of the adsorbed water by heating, the desiccant is again ready to go about its job of drying gas. Therefore, because of the cyclic nature of operation, it is customary to have two or more drying towers operating in parallel, with one tower going through the reactivation cycle, and at least one on the drying cycle, at all times. In many fields of operation, the desiccant can be used for thousands of these cycles and still do a satisfactory job of water removal. In fact, the first activated alumina, Grade F, ever sold by Aluminum Company of America over 20 years ago, is still in use. In other fields, such as the dehydration of natural gas, the desiccant will experience a decline of capacity with use, and the "life" of the desiccant will be important economically. From the above, it can be seen that a desiccant of high moisture holding capacity, and high retention of this capacity in use, would be the most desirable. A new product, Activated Alumina H-151, gives great promise of filling these needs most ably.

History of New Product

Experimental work has been carried out by Alcoa for a number of years on the manufacture of a gel type alumina. Briefly, this manufacture consists of the mixing of sodium aluminate solution with sodium bicarbonate solution, and the filtration, washing, drying and activation of the gelatinous mass thus formed. This new material has been given the designation activated alumina, H-type. Pilot plant batches of this gel-type alumina have shown a marked increase in water sorptive capacity over that of the F-type activated alumina, which has been in use for some time. H-type material in granular

†Presented before the Gas Hydrate Control Conference, Norman, Oklahoma, May 1953.

[1]Aluminum Research Laboratories, East St. Louis, Illinois.
[2]Continental Oil Company, Lafayette, Louisiana.
[3]Aluminum Company of America, New Orleans, Louisiana.

form did not prove satisfactory, however, as it showed excessive particle breakdown.

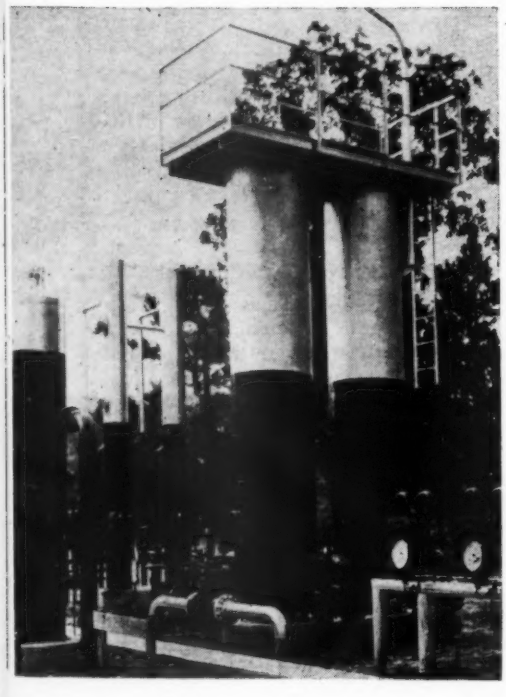
In order to overcome this weakness and to obtain other desired characteristics, for several years considerable work was devoted to ball-forming this gel-type alumina. The result was a product of superior physical properties. This successful accomplishment, along with the high sorptive capacities found for the gel type material, has indicated that alumina gel balls would be very well suited to the drying of high pressure fluid streams, such as natural gas. However, before releasing this product, designated Activated Alumina H-151, to the market, it was considered advisable to conduct a comparative test with the competing gel desiccant under actual field conditions.

Description and Operation of Installation

This field test was made at the Reddell Separator Station of Continental Oil Company, located four miles northwest of Reddell. This separator station receives natural gas from 17 wells in the area, with the average pressure at the well site being 2400 psi. The normal flow from this field averages 16 to 19,000,000 std cu ft per day. Upon arrival at the separator station, the gas is expanded to approximately 850 psi. It then enters a number of separators where free water and distillate are removed.

The gas streams from the individual separators are combined and flow through a master separator where any additional liquid is removed. At this point the gas is free of any liquid, but is saturated with water and distillate vapors at the prevailing conditions of temperature and pressure. The gas stream then passes through the dehydration tower, where the water is removed by the solid desiccant. The dried gas is metered and then recombined with the distillate for transmission to a gasoline plant.

Dehydration towers used for tests.



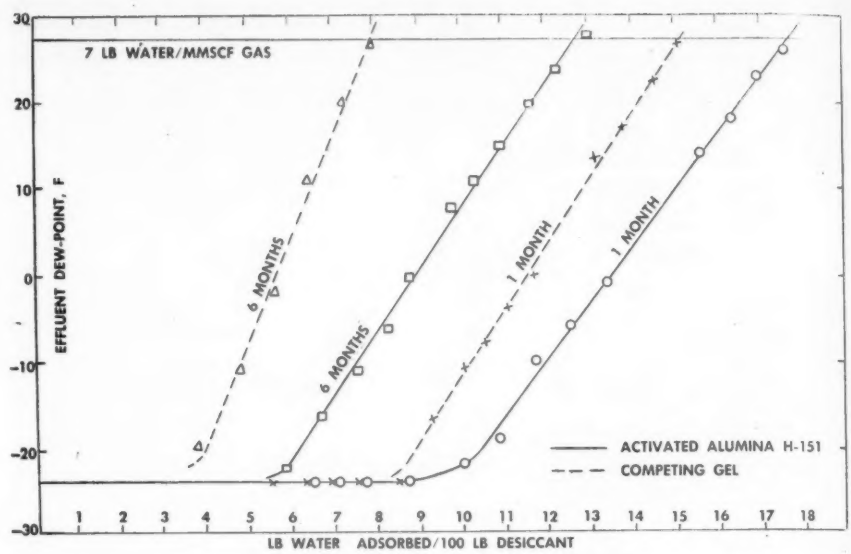


FIG. 1. Capacity test data for activated alumina H-151 vs competing gel — Data for 1 month and 6 months' tests.

A twin-tower dehydration unit was used for this test. Each tower of this unit is 16 ft high and 3 ft in diameter. Wet gas enters the tower at the bottom through a 4-in. pipe, which extends above the top of the bed through the centerline of the tower. The gas is deflected downward through the bed by a bonnet at the top of this pipe. The dried gas leaves at the bottom of the tower.

Reactivation of the spent desiccant is accomplished by passing natural gas heated to approximately 360 F through the bed, counter-current to the flow of the drying cycle. In normal operation, the towers at Reddell are switched every eight hours. A tower is reactivated for six hours and cooled for two hours before being placed on the drying part of the cycle.

Test Procedure

On April 11, 1951, one tower of this unit was charged with approximately 4000 lb of the competing gel dessicant, 4-8 mesh size. Approximately the upper 10 per cent of the bed was filled with a new form of the competitive gel, said to show high resistance to decrepitation when in contact with liquid water. The other tower was charged with 3900 pounds (equivalent height) of H-151 Activated Alumina gel balls, ¼-in. to 6 mesh.[1]

The first test on H-151 was made on April 14, 1951, after the bed had completed four drying cycles. The first test on the competing gel desiccant was made on April 18, 1951, after this bed had completed eight drying cycles. During this "break-in" period, the beds were operated at approximately one-third their capacity. For a test, the particular tower being tested was allowed to continue on stream without interruption until the water content of the effluent gas had gone above 7 lb per 1,000,000 std cu ft. This quantity of water vapor is usually the standard allowable in the gas transmission industry, and will be taken as the basis of comparison for these tests.

During a run, the water vapor contents of the inlet and the outlet gas from the dehydrator were determined at periodic intervals. The water content of the inlet gas was determined by the inlet temperature and pressure. The water content of the outlet gas was determined by its dew-point and pressure. Dew-points were determined by the use of a Bureau of Mines high pressure dew-point tester, using liquid propane as the coolant. The absolute water contents in pounds per million standard cubic feet were derived from a chart of water vapor content at saturation versus temperature at various pressures.[2]

Gas flows were calculated from the readings on the orifice meter chart by the method given in a booklet by American Meter Co.[3]

Capacity test runs were made on each tower a total of six different times. In addition to the data taken shortly after charging the towers, test runs were made after approximately 1, 3, 6, 13, and 20 months of operation.

On two different occasions, once after one month's operation, and again after six months' operation, the towers were opened and samples of the desiccant material removed from the the top of the beds. These samples were returned to Alcoa's Aluminum Research Laboratories for screen analysis and determination of crushing strength.

Data and Results

Fig. 1 presents the detailed data for two runs each on H-151 and the com-

[1]The material charged to the tower was originally designated as XH-151 because it was produced in the pilot plant and was not in commercial production at the time of charging.

[2]McCarthy, E. L.; Boyd, W. L.; and Reid, L. S.; "Water Vapor Content of Natural Gas at Saturation," presented at San Antonio Meeting of AIME, Petroleum Branch, October 6, 1949.

[3]"Orifice Meter Constants," Handbook E-2, American Meter Company, Erie, Pennsylvania.

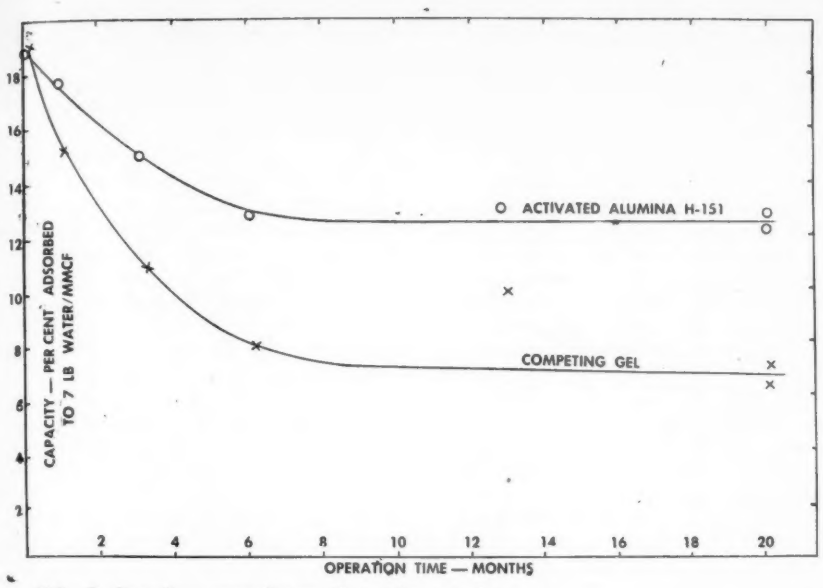


FIG. 2. Sorptive capacity vs time of operation — Reddell dehydration test.

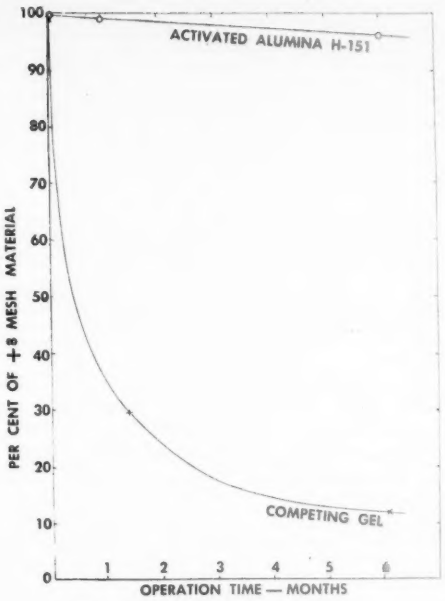


FIG. 3. Disintegration of desiccants at inlet side of towers.

peting gel tested. In this plot, calculated capacity, or per cent absorbed, is plotted versus effluent dew-points.

A summary of the capacity data through twenty months of operation is presented in Table 1 and graphically in Fig. 2. Seven pounds of water per million standard cubic feet of gas, which corresponds to a dew-point of approximately 27.5 F at these conditions of temperature and pressure, has been selected as the parameter for this summary.

The results of screen analyses and crushing strength determinations on the samples removed from the towers at the one and six months' points are given in Table 2. Fig. 3 presents graphically the amount of breakdown of the two materials.

Discussion of Results

It can be seen from Fig. 1 that the typical run consisted of a fairly long period of constant effluent dew-point, which for all runs was below 20 F; a "break-point", when the adsorption "front" reached the exit end of the bed; and then a period of constant rise in dew-point. Curves of this type were made for all the test runs but are not included in Fig. 1 in order to keep it readable. The point at which the effluent dew-point curve crosses the line for 7 lb water per 1,000,000 std cu ft was taken as the parameter for comparing the data in Table 1 and in Fig 2.

Fig. 2 is really the "meat" of this paper and presents graphically the life histories of the two desiccants, so far as capacity is concerned. It can be seen that both desiccants started off with approximately the same sorptive capacity and that both experienced a decline in capacity for the first six months. This rate of decline was much greater for the competing gel than for H-151, with the result that after six months of operation, the capacity of the H-151 was 12.7 per cent, whereas that of the other gel was only 7.9 per cent. The curves for both desiccants then began leveling out, with practically no further decrease in capacity for the H-151 through the 20 months' point, and only a small decrease for the competitive gel desiccant. Data for the thirteenth month's test run were disregarded when the performance curve (Fig. 2) was drawn. When this test was made, the Reddell unit was operating at a flow rate of only 10 to 11,000,000 cu ft of gas per day, whereas normal flow was approximately 16 to 18,000,000 cu ft per day. Another peculiarity of this test was the low inlet gas temperature. This temperature was as low as 68.5 F during this time, as compared to an average inlet gas temperature for the other runs of 82-84 F. This lower temperature, of course, meant less water per cubic foot of gas. The combination of decreased flow and decreased water content of the gas caused the water entering the bed to be only about 40 per cent of that entering normally. Data for this test run can therefore be disregarded, as the conditions of the test were not representative. The flow for the H-151 run during the 13 months' test was closer to normal than for the competing gel run, and the point representing this run falls correspondingly closer to the overall performance curve.

TABLE 1. Sorptive capacity data— H-151 versus competing gel.

Date of test	Months of operation	Per cent adsorbed* H-151	Per cent adsorbed* Competing gel
April 1951	0.1	18.8	19.0
May 1951	1.2	17.6	15.2
July 1951	3.3	14.9	10.8
October 1951	6.2	12.7	7.9
May 1952	13.0	12.8	10.0
December 1952	20.0	12.5	7.0

* Per cent adsorbed to bring the gas to not over 7 lb water per MMSCF.

TABLE 2. Particle breakdown and crushing strength of samples removed from towers.

Mesh size	H-151 As charged %	H-151 After one month service %	H-151 After six months service %	Competing gel As charged %	Competing gel After one month service %	Competing gel After six months service %
+4	82.0	84.9	70.8	9.2	0.0	0.0
4–8	17.9	14.3	24.8	90.3	29.5	12.1
8–14	0.03	0.76	4.3	0.5	59.5	64.7
14–20	0.01	0.02	0.1	0.0	6.8	16.8
20–28	0.01	0.01	0.01	0.0	2.65	4.2
28–42	0.01	0.01	0.0	0.0	1.23	1.5
−42	0.01	0.03	0.04	0.0	0.36	0.8
Total	99.97	100.03	100.05	100.0	100.04	100.1
Crushing strength, per cent	55.1	45.0	45.2	64.1	29.6	30.8

It will be noticed from Fig. 2 that two runs were made for each tower after 20 months of operation. Data within each set provide good checks with one another. During these latter tests the flow rates for both of the competing gel runs were held constant at approximately 16,000,000 cu ft gas per day. For the two runs on H-151, the flow rates both averaged 19,400,000 cu ft per day. This higher flow rate had no deleterious effect on the capacity of the H-151.

After 20 months of operation, the capacity of the H-151 was 12.5 per cent, and the capacity of the competing gel was 7.0 per cent. The capacity of the H-151 was therefore approximately 80 per cent greater than that for the other gel tested. This higher capacity for H-151 would enable existing units to run for longer cycles, with a corresponding decrease in reactivation cost, or at higher capacity, which would allow additional wells to be brought in. It would also allow the design of smaller sized drying towers for new units on a particular job. Any of these, of course, would represent real savings.

It is interesting to note that the 7.0 per cent capacity for the competing gel after leveling out is very close to the 7.5 per cent capacity figure for this material, used by many design engineers when

specifying equipment. The gas dried at this installation is a typical Gulf Coast gas, containing approximately 90 per cent methane by volume. The fouling characteristics of this gas can be considered about average as evidenced by the 7.0 per cent capacity for the competitive gel after leveling out.

Because of the set-up at this particular separator station, where the distillate recovered is recombined with the dried gas for transmission to a gasoline plant, no study of the distillate recoveries of the two types of desiccants could be made.

As stated previously, the towers were blown down and opened for sample removal at the end of one month and again at six months. A visual examination of the material in the top of the beds showed that the competing gel had broken into relatively small pieces, whereas the H-151 balls had suffered little or no breakage. This fact is borne out in the screen analyses of these samples, along with that of the material as charged, which appear in Table 2. These data are graphically presented in Fig. 3, which demonstrates the minor breakdown of the H-151 gel balls as compared to the other gel. It is seen that at the end of six months' operation, over 95 per cent of the H-151 was still larger than 8 mesh, whereas only 12 per cent of the competitive gel could make this claim.

It is to be emphasized that the other type gel charged to the top of the tower, and from which these samples were taken, is the relatively new form which is supposed to resist decrepitation from liquid water. In beaker tests conducted in the laboratory, approximately 75 per cent of fresh particles of the new form of the competing gel showed breakage or cracking after three wettings with water and alternate dryings in room air. The presence of hydrocarbons before the water wetting was found to accentuate this breaking, and caused essentially all the particles to break within a few reactivation and wetting cycles. The turbulent motion of the incoming gas stream could then break the cracked particles into the small fragments that were present in the top of the tower.

This particle breakage is important because of the resulting large pressure drop through equipment containing small particles. There is no way of measuring the actual pressure drop through the beds at this installation. However, there are pressure taps available upstream, and at some distance downstream from the dehydrating towers. At the time of the six months test, these pressures were measured during the runs on each tower with the same calibrated pressure gage. The pressure drops so measured were found to be 60 psi and 35 psi for the competing gel and H-151 beds, respectively. If the pressure drop through the piping, elbows, flanges, orifice plate, valves, entrance and exit losses, etc., can be assumed to be approximately 25 psi, this would mean that the pressure drops through the actual beds were 35 psi for the competitive gel and 10 psi for the H-151. This difference could mean increased pumping costs in some installations.

The crushing strengths of the samples removed from the towers are also listed in Table 2. The test for this property consists of subjecting a weighed sample of 4-8 mesh material to a pressure of 1000 psi for one minute, and then measuring the amount of plus 8 mesh material remaining. The ratio of the weight of this fraction to the original weight is called crushing strength, and is expressed in per cent. Desiccant, H-151, had an original crushing strength of 55 per cent, dropped to 45 per cent in one month, and was still the same after six months. The per cent decrease in crushing strength was therefore approximately 18 per cent. The competing gel, as charged, had a crushing strength of 64 per cent. At the one and six months' points of operation, the crushing strength of the competing gel had dropped to approximately 30 per cent; this represented a 53 per cent decrease from its original crushing strength.

Towers have not been opened for material inspection since the six months' test. Inasmuch as only the top level of the bed can be sampled, it was felt that little could be gained by extracting further samples until the whole bed could be sampled. This will probably not occur until the desiccants in the towers are no longer able to meet the specifications required of the gas at this installation. Having been designed for a lower capacity desiccant, these towers are still able to give satisfactory performance, even with the large decrease in capacity noted for the tower containing the competing gel. When the final test run is made, and the towers are emptied, additional useful information should be gained. It appears, however, that the H-151 is set for a very long life at its present operating level of approximately 12.5 per cent sorptive capacity.

Conclusions

The following conclusions can be drawn from the results of this full-scale field test comparing the new H-151 Activated Alumina gel balls with the competitive gel in the high pressure dehydration of natural gas:

1. Activated Alumina H-151 and the competing gel tested had practically identical initial capacities.
2. Rate of decline in capacity for Activated Alumina H-151 is much smaller than that for the other gel tested.
3. After 20 months of operation, Activated Alumina H-151 had an 80 per cent greater sorptive capacity than the competitive desiccant tested.
4. For conditions similar to those encountered during this test, a design figure of 12 to 12.5 per cent sorptive capacity for Activated Alumina H-151 can be applied.
5. At the end of six months of operation, Activated Alumina H-151 showed little evidence of particle breakdown.
6. The decrease in crushing strength of Activated Alumina H-151 was approximately only 18 per cent.
7. A very long "life" is indicated for the new Activated Alumina H-151.* *

Rocky Mountain Oil Activity at New High

The oil industry in the Rocky Mountain region has completed the most active six months in history, according to Petroleum Information. Accomplishments indicated that the year's activity will be by a wide margin the largest in exploration, drilling, and production ever experienced.

Rocky Mountain activity during the first half of the year was maintained at levels in excess of the previous record year of 1952 despite an evident reduction in activity in the nation as a whole.

More than 265 rotary rigs were active as of the first of July in the Rockies. Previous record was 274 active units, a level which was reached for a short time in the late summer of 1952.

Completions in the first six months of the year numbered 1377; of these 959 were development wells, and 418 were wildcats. Development completions during the first half of the year produced 508 oil wells, 300 gas wells, and 151 dry holes for an infield success ratio of 84.2 per cent.

The 418 wildcats completed during the first half of the year resulted in 43 oil discoveries, 16 gas discoveries and 359 dry holes for a success ratio of 14.1 per cent for the region. Ninety-six discoveries of all types were completed in the region in 1952.

During the first half year Colorado had 22 discoveries, Montana 3, Western Nebraska 13, Northern New Mexico (San Juan Basin) 6, North Dakota 3, Utah 2, and Wyoming 10.

A total of 7,049,331 ft of hole was completed in the region to July 1, which compares with an annual total of 11,570,044 ft in 1952. On the basis of previous performance a total of approximately 17,000,000 ft of hole will probably be drilled in the region during the entire year.

Discoveries in the deeper horizons of the Denver-Julesburg Basin of Colorado and Nebraska, on the east side of the Big Horn basin in Wyoming, and in the Williston basin of Montana and North Dakota were of major importance and appear certain to assure a continued high level of activity during the remainder of the year and for some time to come.

Development drilling was highest in Wyoming. Colorado and Nebraska led in number of wildcat wells drilled during the first half of the year, with Wyoming a close third. North Dakota, newest producing state in the region completed 100 development wells and 26 wildcats during the first six months of the year.

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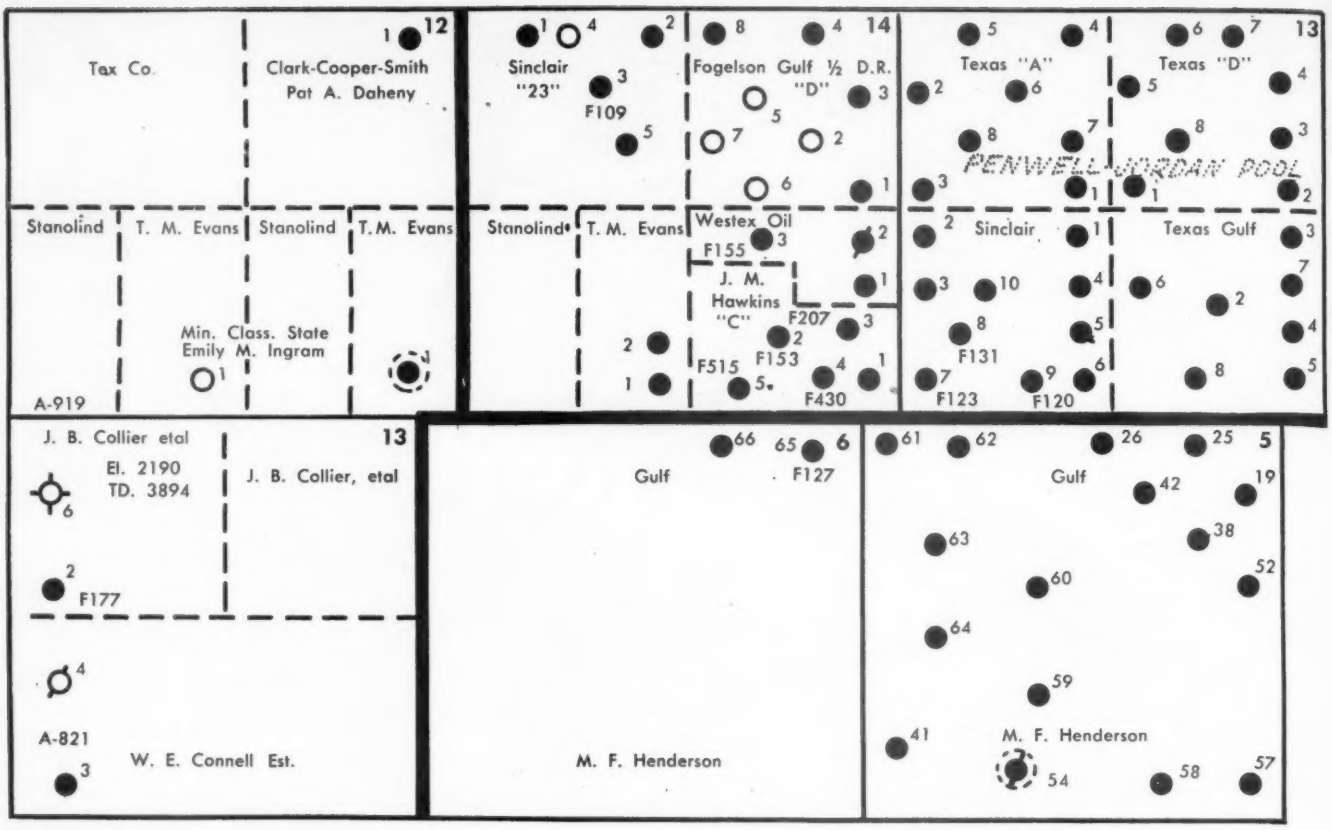
PHOTOGRAPH OF MAGCOGEL MUD



LOCATION of "Ingram-Jordan No. 1" on west flank of Penwell Jordan pool, Crane County, Texas.

New Oil Horizon Extends Penwell Pool

Discovery of deeper producing zone may force the re-evaluation of much west flank acreage

JOHN V. TOWNSEND, JR.

THE T. M. Evans Jordan-Ingram No. 1 was completed as a flowing oil well through casing perforation from a Detrital chert section of Pennsylvanian age June 14, 1953. Situated 660 ft out of the southeast corner of section 12, block 22, P. S. L. Survey in Crane County, Texas, it had spudded March 23, 1953 as an Ellenburger test. The rig, an Emsco 750, is owned by the Goal Tullous Company of Midland, Texas. Drilling supervision was by "Hap" Howard of Odessa. This potentially important flank discovery along the west edge of the Penwell-Jordan pool could force the re-evaluation of much flank acreage not previously held in too high regard.

The casing program was planned so that 13⅜-in. surface casing, 9⅝-in. intermediate casing, and 7-in. oil string would be used. A 17¼-in. surface hole was drilled to 365 ft using fresh water and gel. Surface pipe was set at this point and cemented with 300 sacks of regular cement with 2 per cent gel. A 12¼-in. hole was then drilled to 4124 ft using a saturated salt drilling fluid. At this depth, 9⅝-in. casing was set with 2500 sacks of 50 per cent posmix and 200 sacks of neat cement. Drilling then proceeded in an 8¾-in. hole to the total depth of 9068 ft, fresh water being used as a drill fluid to 6500 ft and the rest of the hole being drilled with gel, caustic, and quebracho mud. No commercial shows being encountered below 8425 ft, the 7-in. oil string was swung at that point and cemented with 765 sacks of Trinity Slo-set.

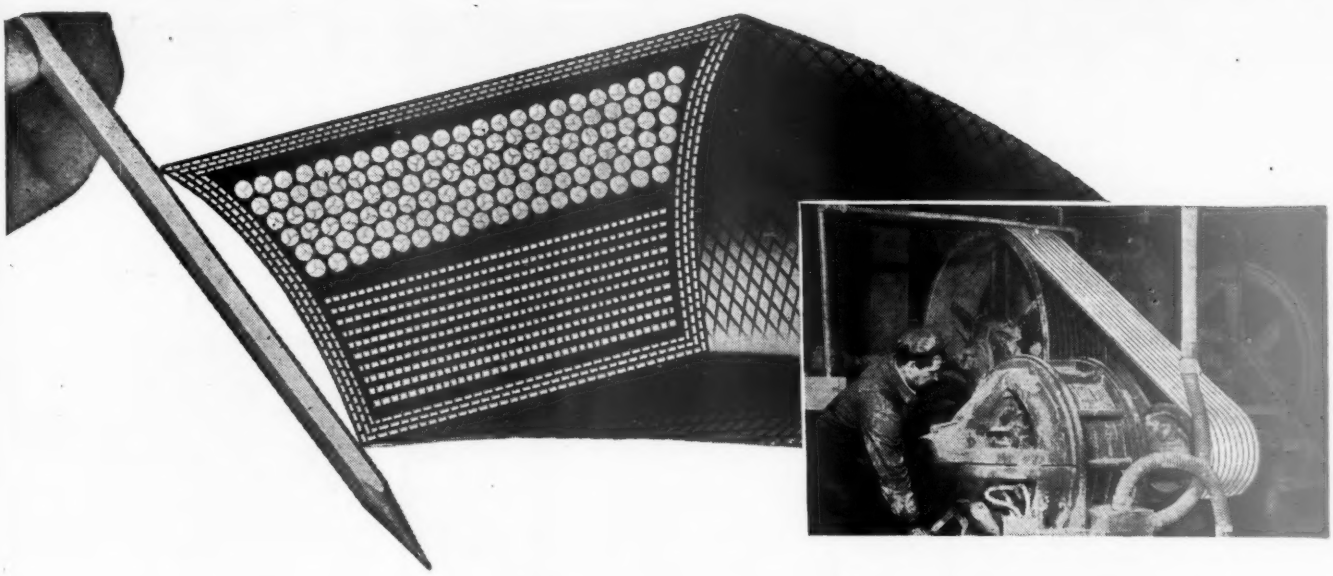
The San Andres formation topped at 3480 ft, was cored and was found to contain shows of oil and gas, but analysis of the cores proved the formation to be low in porosity and permeability. Other oil shows in the Permian section were drillstem tested but were found to be non-productive.

When drilling reached the base of the Permian section, sediments of questionable age were encountered. These sediments consisted of shale, limestone, and chert. It was in a porous chert zone that a drillstem test indicated flowing oil production. The packer in this test was set at 7830 ft with the bottom of the hole being 7845 ft. Gas was noted at the sur-

The Author

John V. Townsend, Jr., was graduated from Oklahoma A&M, Stillwater, Oklahoma, in 1949, with a BS in geology. Employed by Humble Oil and Refining Company, Tyler, Texas, three and one-half years as production geologist, he is now associated with Evans Production Corporation as a geologist and is presently engaged in the supervision of Evans' Crane County operations.

EXCLUSIVE



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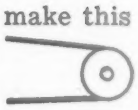

As the belt bends, grip its sides between your fingers and thumb.

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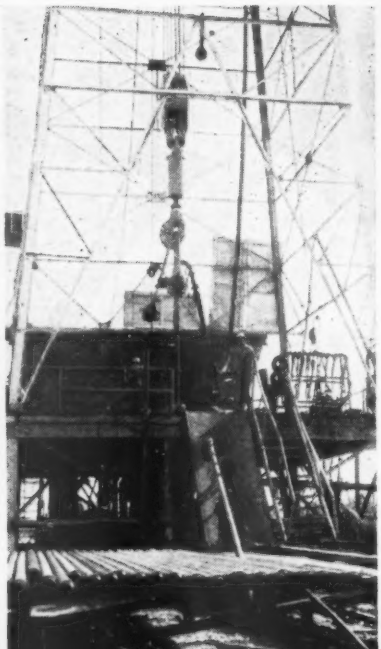
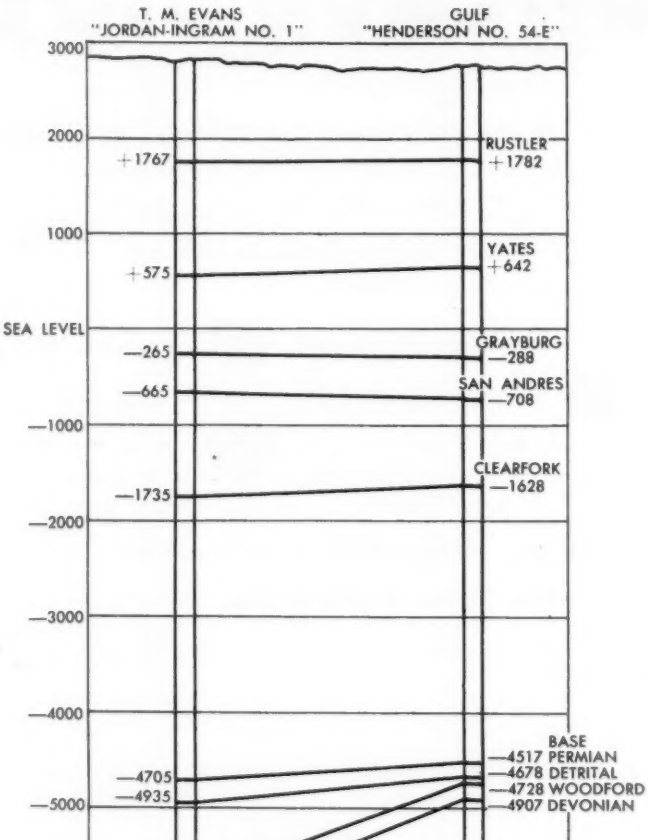
face within 7 minutes after the tool was opened and oil surfaced in 35 minutes. The well was allowed to flow long enough to estimate its producing rate at 40 bbl per hour. Flowing bottom hole pressure was 2725 psi. After a 15 minute shut in, the test instrument recorded a bottom hole pressure of 3300 psi. Test was conducted with a $\frac{5}{8}$-in. bottom and a $\frac{1}{2}$-in. top choke. Drilling proceeded to a total depth of 9068 ft in the Devonian where considerable salty sulfur water was recovered on a drillstem test. Since the well was running structurally low to other deep penetrations in the area, it was decided to plug back and attempt a completion in the Pennsylvanian Detrital section, from which oil had flowed on the earlier drill stem test.

Casing was run and perforated opposite the porous chert section from 7828 ft to 7858 ft with 4 Jet shots per foot and the well was completed as a new discovery June 14, 1953. Initial production was 242.06 bbl of 40.30 gravity oil in 24 hr through a 10/64-in. tubing choke. The gas-oil ratio was 558 cu ft per barrel. According to present knowledge, the nearest production from an equivalent or near-equivalent formation is in the Three-Bar field, approximately 35 miles to the northwest in Andrews County.



HAP HOWARD, left photo, toolpusher; John Townsend, geologist; and Raymond Edwards, driller on Goal Tullous rig.

GOAL TULLOUS rig, right, in action on Ingram lease.



STRATIGRAPHIC relation of Evans "Jordan-Ingram No. 1" to Gulf "Henderson No. 54-E."

Listed below are the formation tops from the Evans Jordan Ingram No. 1:

Jordan-Ingram No. 1	Gulf Henderson No. 54-E
Elevation 2815′ D. F.	2782′ D. F.
Top Rustler 1048′ (+1767′)	1000′ (+1782′)
Top Yates 2240′ (+575′)	2140′ (+642′)
Top Grayburg 3080′ (—265′)	3070′ (—288′)
Top San Andres 3480′ (—665′)	3490′ (—708′)
Top Clearfork 4550′ (—1735′)	4410′ (—1628′)
Base of Permian 7520′ (—4705′)	7300′ (—4517′)
Top Detrital 7750′ (—4935′)	7460′ (—4678′
Top Barnett 7895′ (—5080′)	Not present
Top Miss. Ls. 8370′ (—5555′)	Not present
Top Woodford 8595′ (—5780′)	7510′ (—4728′)
Top Devonian 8839′ (—6024′)	7690′ (—4907′)
Total Depth 9068′ (—6253′)	Below 10,060′ (—7278′)

The presence of Barnett shale and Mississippian limestone in the Jordan-Ingram No. 1 and the absence of these formations in the Henderson No. 54-E indicate that deposition was continuing in the area of the Jordan-Ingram No. 1 when erosion or non-deposition was taking place in the area of the Henderson No. 54-E. There are areas in the Jordan field where the Permian lies directly on the Devonian with the top of the Devonian missing. Since the Devonian has been subjected to erosion in this area, this is probably the source of the chert found in the Detrital section in the Jordan-Ingram No. 1. The oil accumulation in the Jordan-Ingram No. 1 is evidently due to a stratigraphic type trap and further drilling will be necessary to properly evaluate and define this new discovery. ★ ★ ★

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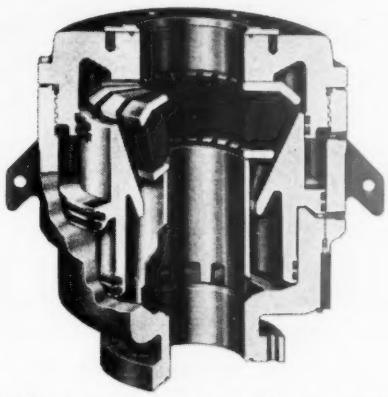

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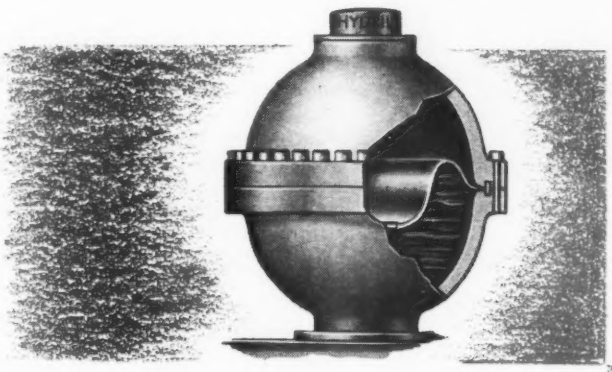
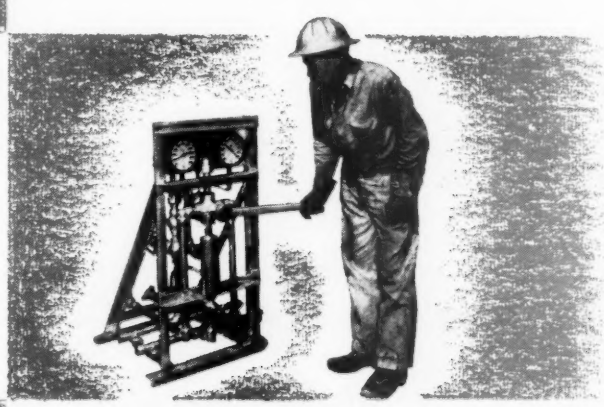
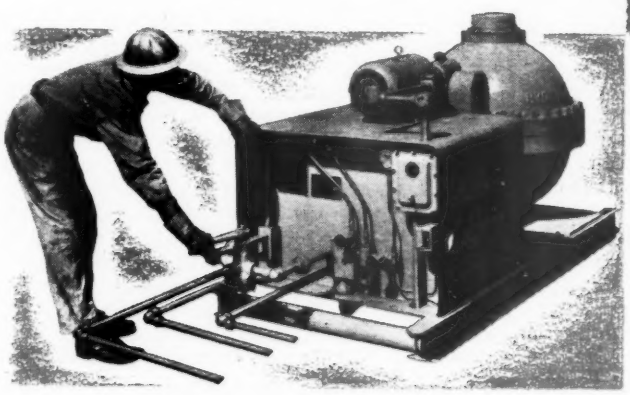


2 to a **HYDRIL AUTOMATIC PUMP ACCUMULATOR UNIT** which stores hydraulic fluid under high pressure, keeping it always ready for instant closing of the Blowout Preventer...



3 then – in any emergency – pull a single lever at **DRILLER'S CONTROL STATION**



4 or at the **REMOTE CONTROL STATION** mounted on the Automatic Pump Accumulator Unit at a safe distance from the well. Controls are foolproof; regardless of which one is operated, the Blowout Preventer will always close...

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Oilwell 96 drawworks on new deep drilling rig recently acquired by Bell and Burden, Inc., California contractors. Rig is already working in Ventura area.

Contractor Expands Deep Drilling Facilities

Bigger rigs with greater flexibility seem to be in demand for future operations on West Coast

RICHARD SNEDDON*

CALIFORNIA drilling contractors have certainly no qualms about the future of their industry if one is to judge by the size of recent investments in heavy-duty, deep drilling equipment. Latest to add to its ultra modern facilities is Bell and Burden, Inc., Los Angeles, contract drilling firm, which, continuing an established policy of deep well specialization, has purchased its fourth big rig, reputedly for a sum not too far from half a million dollars. The three deep drilling outfits already owned by the company are all capable of penetrating the good earth to a depth of 13,000 ft plus, and this latest acquisition, an Oilwell 96 drawworks with four engine compound and all the other integrated accoutrements, is designed to reach into the subsurface some 16,000 ft plus.

The new rig is presently drilling in the Ventura Avenue field, and it is in all respects an impressive assembly. It looks, indeed, more like a drilling works or plant than a mere rig. The drawworks has a drum, 28 in. in diameter and 47 in. long, that is equipped with a groove bar for a 1⅜-in. wire line, and also features a 46-in. hydromatic brake. The brake bands are 54 in. in diameter and 11½ in. wide, and the 306 deg hand brake is of the self-energizing type that has the capacity to stop and hold maximum loads with the very minimum of manual effort.

Drawworks and pumps are powered by four 12-cylinder Hall Scott gas engines equipped with Torcon torque converters and delivering a total of 1600 hp through an Oilwell 4-engine drive that provides a medium for compounding power and distributing it in any desirable combination or direction. The engine and drive are mounted on a 4-ft high structural steel base, which, in turn, is connected to the 10-ft high base that carries the 143 ft, 650,000 lb hook load, full-view Ideco mast. The four engines are mounted individually on skids for quick removal when that might become necessary, and the entire set-up has been integrated and streamlined so as to be more than usually portable, and to simplify rigging up and tearing down to the greatest possible extent.

The rig features a pair of 8-in. by 20-in. duplex power slush pumps, chain operated from the engine drive. These, too, are mounted on steel skids, attached to the engine bases for alignment. The drives to the rotary table and pumps have fully enclosed oil-bath guards, and are so compounded as to permit the operation of either individually, or both at one time. It is anticipated that these large pumps with high horsepower output will be of great benefit when jet bits are being used and high mud velocities are of primary importance.

Besides the mud pumps, there are three water circulating pumps in the cellar furnishing jacket water for the engines, the hydraulic brake, and other miscellaneous purposes. Two heavy steel plate towers are employed for the cooling of engine radiator, exhaust jacket, and hydromatic brake water; and in addition to the shaft-driven compressor that provides air for the actuation of clutches and brakes, there is a standby electrically operated unit to take care of the remote possibility of failure in the engine driven set-up.

This precautionary measure is typical of the safety consciousness that prevailed when the total entity was designed. Every effort was made, not only to meet California state safety regulations, but to remove as many as possible of the normal drilling hazards. Needless to say, the handling of heavier loads for deeper drilling adds distinctly to the dangers of operation, but California contract drillers, as a group, have exerted themselves ceaselessly and with good effect to the elimination of job hazards.

In this connection, it is worthy of mention that in order to dissipate any possible accumulation of flammable gases, the engines are equipped with pusher type fans that force air through the engine assembly, indeed, flush the entire engine area, and all other vulnerable sections of the rig. Fire hazard is still further reduced by the installation of water-jacketed coolers on the engine exhaust lines.

The mud system is a thoroughly up to date one with two 22½ sq ft screens, and parallel steel ditches from the screen tanks to the mud suction tank, so that when it becomes necessary one of the ditches may be blanked off and cleaned without interrupting the operation. Facilities for mud modification, or treatment, are simple and convenient, and are calculated, in all respects, to permit the mud engineer to perform his function efficiently and with the minimum of interruption.

Other important accoutrements of the rig are the rotary table, traveling block, and swivel, all of which are of heavy duty caliber. The hook is of 300-ton capacity, and tongs and other derrick floor essentials are of well recognized and reputable types. The control panel,

*Pacific Coast Editor.

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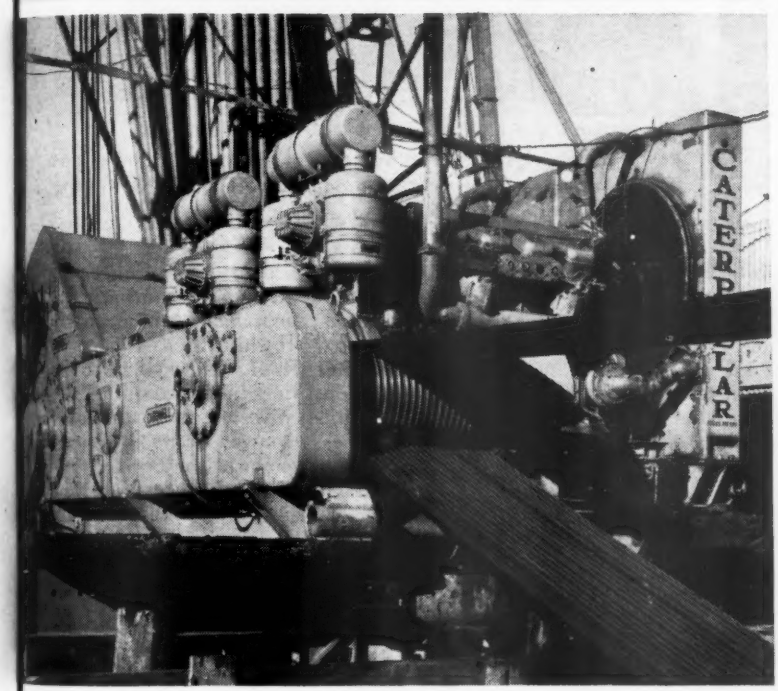
BOTTOMED AT 10,805 FEET...

READY FOR AN EASY MOVE



In Williston Basin, this hole was bottomed at 10,805 feet by Taylor Drilling Company, Lewiston, Mont. The next move is easy because the operation is entirely powered by Caterpillar Oilfield Engines and an Electric Set.

This drilling contractor compounded his two D375 Diesels to a Cardwell Model "O" Rig and a Gardner-Denver 7¾" x 16" mud pump. The Cat* D3400 Electric Set provided power for auxiliary motors and lights.

By standardizing, the company saved money and assured itself of dependable drilling power, good service and quick moving time.

The two D375 Diesels provide an honest intermittent rating of 670 HP for hoisting under maximum conditions. In addition, they are easy to move.

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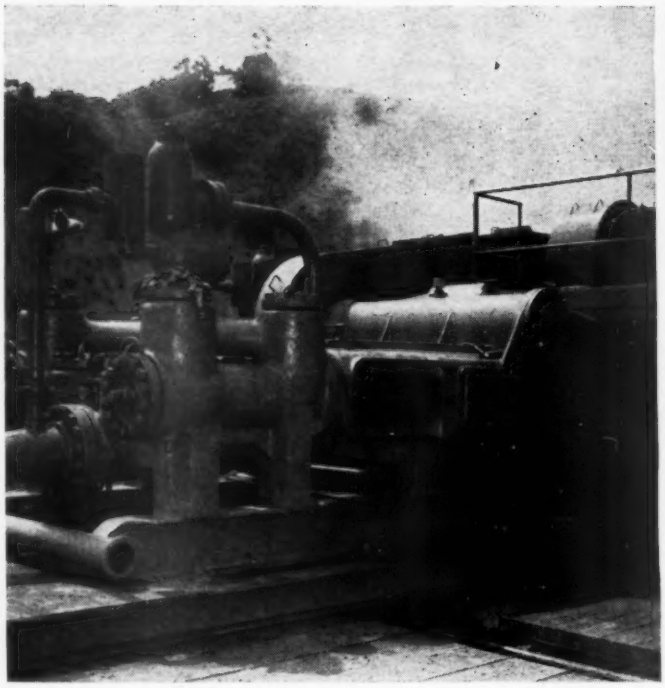

One of 8-in. by 20-in. Oilwell No. 220P slush pumps. These are chain opearted from engine drive, and are mounted on skids for easy movement.

Power for big rigs is derived from four Hall Scott 12 cylinder gas engines equipped with Torcon torque converters and delivering 1600 hp through an Oilwell four-engine drive.

of the latest approved species, is capable of providing readings throughout the operation of the weight on the hook, the torque on the string, the speed at which the bit is turning, and the pressure at the mud pump discharge. Below the derrick floor, besides the water circulating pumps already referred to and the general substructure, are a high pressure blow-out preventer and a valve assembly featuring a pair of hydraulic control gates.

Included in the accessories and a most important consideration, are approximately 13,000 ft of 4½-in. grade E. flashweld tool joint drill pipe. The mast can actually rack 16,000 ft of 4½-in. drill pipe, or 23,000 ft of 3½-in., and the available horsepower is ample to permit drilling to these depths.

Unitization of the rig has been worked out to the nth degree by Harry Buchanan, vice president and manager of Bell and Burden, Inc., together with engineers from Oilwell Supply Company and the other equipment concerns involved. The drawworks, engines, and engine drive, are so distributed on skids that they can be loaded out in four heavy truck loads for movements within the field, while for more distant moves the engines can be completely removed from the skids. Most of the derrick piping, incidentally, has been built into the skids and substructure, and when a move is in prospect, all that is necessary is to disconnect outside piping by means of handlebar unions.

Ruggedness and flexibility have been carefully engineered into this giant machine. The driller has complete control of operations from his position at the console. Positive air actuation and an easy-to-read instrument panel helps the crew to make more on-bottom hours, and the portability of the drawworks saves much rigging-up and tearing-down time. Actually, no dismantling is necessary when a move is contemplated. Two chains and the air manifold only need to be disconnected from the drive, and the design of the drawworks is such that all working parts are enclosed for protection, yet are readily accessible for maintenance or service work. Also, because the major units in the assembly are unitized, they remain at all times in alignment.

This whole expansion of facilities and extension of usefulness is by no means an unexpected development, although it is a decidedly a consequential one. Bell and Burden, Inc., has always been a keenly alert institution, keeping a sharp lookout for the shadows that forecast coming events, drillingwise. A. H. "Ham" Bell, president, has had a wealth of experience in most of the operating phases of the oil business, and is particularly familiar with the tools and techniques of contract drilling. Since 1947, when he and his partner, Dewey Burden, took over Continental Oil Company's drilling department and formed their own concern, the firm has prospered.

Despite his extended association with the oil industry, or because of it, perhaps, Ham Bell has never ceased to be a student. He has an insatiable appetite for information that might be applicable either technically or otherwise in his own business, and he has both the understanding and daring that enable him to make use of what he learns.

He is a popular writer and speaker on the diverse aspects of the contract drilling art, and has long been a hard working member of the American Association of Oil Well Drilling Contractors. He is a past president of the California chapter and a director of the national body, and as such, has been a prime initiator of worthwhile ideas.

His partner, D. H. "Dewey" Burden, vice president, does not give full time to the administrative affairs of the company, but is a most astute business executive whose counsel has been a pronounced factor in the success of this enterprise. He is widely known and highly respected as one of the country's leading constructors, and tangible evidence of his capability is to be found in the many substantial projects that he has completed for clients in widely scattered areas of the west. He is an organizer of rare ability, and has a reservoir of resourcefulness that would prove an asset to any business organization.

These two principals have assured the continued progress of their organization by surrounding themselves with competent aides. Vice president Harry Buchanan is one of the recognized drilling authorities of the west, with the type of experience background and engineering mind that equip him well to supervise field operations in a completely adequate way.

Chet Wesch, who has been chosen to skipper the new rig, has been toolpusher on the firm's other Oilwell 96, and hence is thoroughly familiar with the handling of these modern giants. He has also had long experience in practical drilling of all modern types and in the handling of drilling crews. Altogether, it appears that Bell and Burden, Inc., is in good shape in the matter of men, tools, and skills to handle the most formidable assignment of today and to anticipate the most exacting requirement of tomorrow. ★ ★ ★

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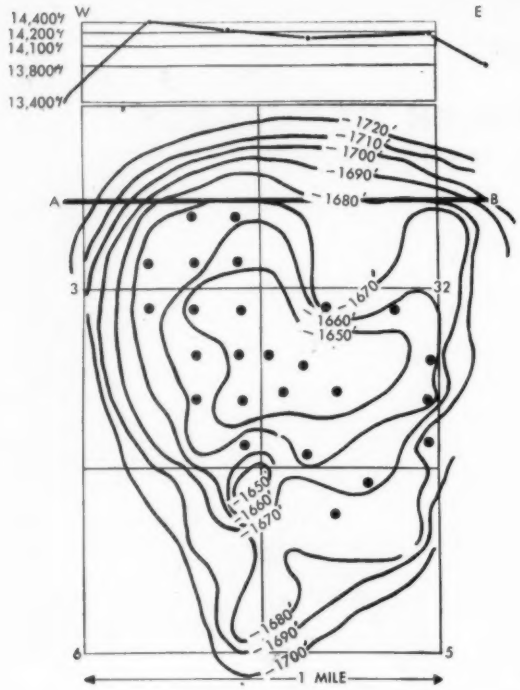
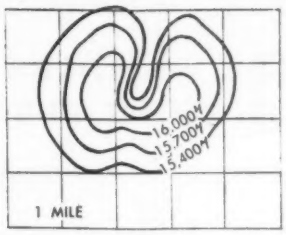


FIG. 1



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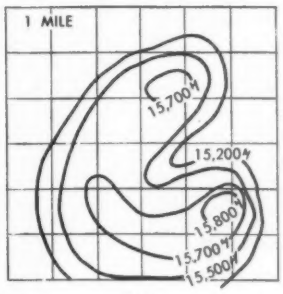

FIG. 3.

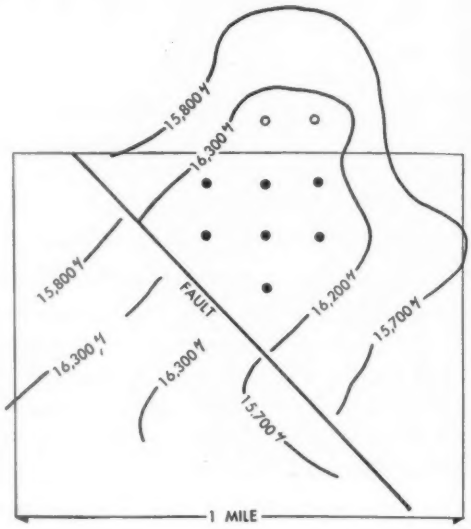

FIG. 4.

MAGNETIC DATA FROM SEDIMENTARY BEDS

Correct interpretation of magnetometer data offers means of determining structure from sedimentary formations

J. L. HARPER

USE of the magnetometer in exploration for ore deposits has been common for many years and is too well known to require comment. In oil exploration, however, it is now erroneously thought of as being useful for basement granite complex measurements only.

For purposes of laboratory practice an experimental table should be constructed. Ore bodies or other structures may be represented by large or small pieces or sheets of steel or iron that have been hardened and magnetized. These should be of different shapes to represent the dikes, lenses, domes or anticlines, or other structures expected to be encountered in the field, either in ore or oil exploration. By placing these metal bodies under the plane of observation in any desired position or distance from the magnetometer most of the field conditions as to terrain can be studied. Then comparison of results as to known disposition, size and depth beneath the plane of observation of the structures will soon become part of a sound background of experience and will enable the operator correctly to interpret field survey data.

Operation of such an experimental table will confer a knowledge of the resulting complex curves that cannot be obtained by theoretical study. Without this thorough experimental work the observer will upon occasion find himself unable to arrive at sound conclusions as to the outline and attitude of complex structural surveys.

From this laboratory study it will be found that sedimentary formations carrying magnetized beds may be used as datum. There are one or more oil field service companies that at present are able to orient cores, as to the direction

EXCLUSIVE

The Author

J. L. Harper is a consulting geophysical engineer in Evansville, Indiana, and Albuquerque, New Mexico. He was educated in several schools in U.S. and foreign countries, including many specialized courses. He spent several years as a licensed engineer in Canada and has had many years' experience as magnetometer operator in most of the oil fields of the U. S., Canada, and parts of Mexico. Harper is author of *Oil-Gas-Geology of Southwest Ohio* and *Resistivity Method of Locating Oil and Gas Pays*, and other scientific reports and articles

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Type B	RH	—	LH
Type F	RH	—	LH

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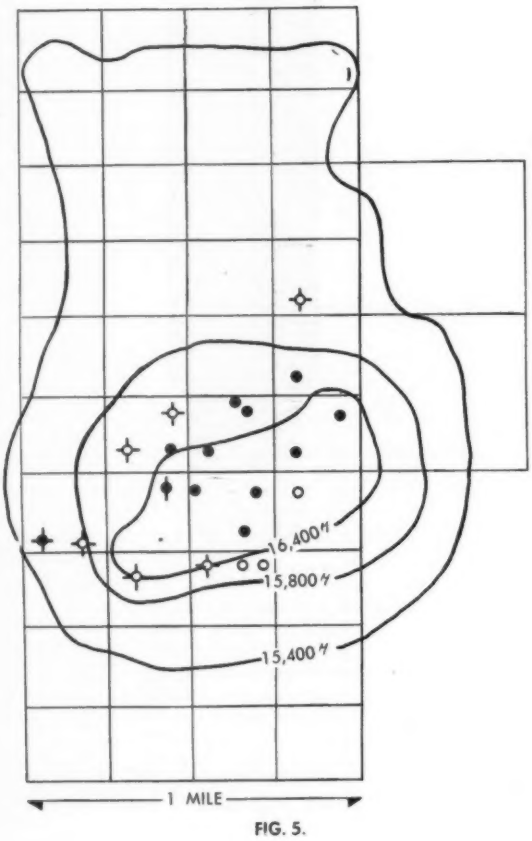

FIG. 5.

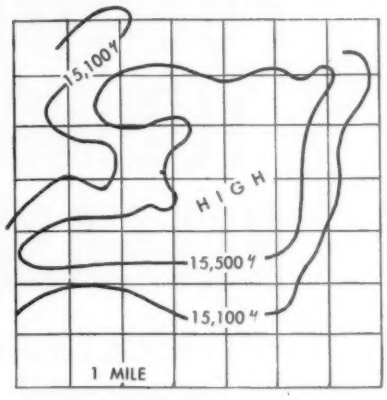

FIG. 6.

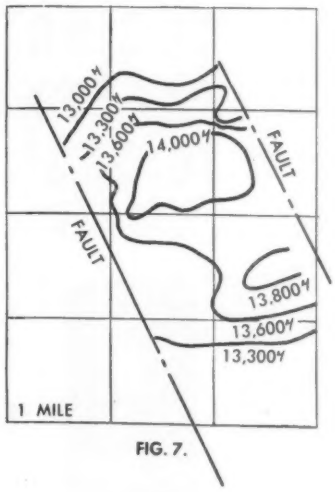

FIG. 7.

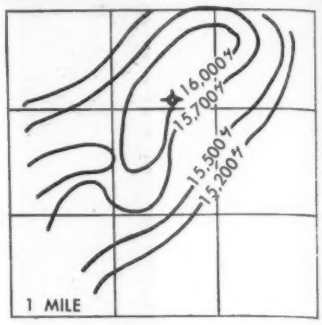

FIG. 8.

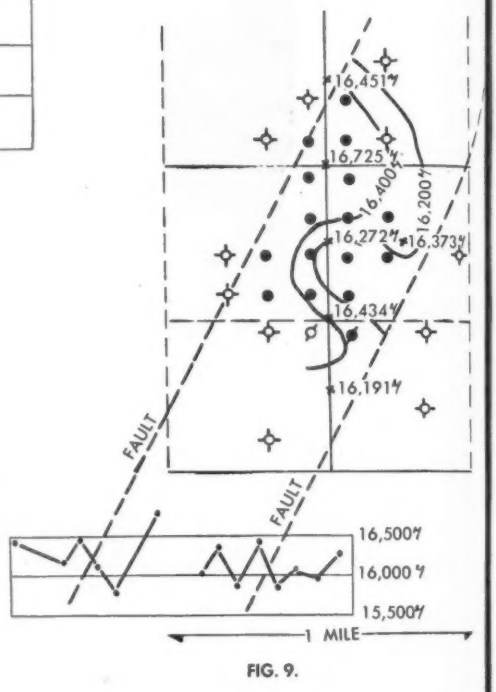

FIG. 9.

of dip, and thus confirming or complementing information of the magnetic field strength variations.

If desired an additional instrument may be carried on the surveys, for purpose of obtaining the outline of the basic granite complex, or airborne surveys, if available, may be used for this purpose.

In mining, knowledge of the depth of the prospective ore bodies is highly desirable. In oil exploration, accumulations are not ordinarily expected in basement complexes, therefore magnetic readings from sedimentary beds must form the basis for test locations.

Organic Reefs

A great deal has been written on the organic reefs and several geophysical methods have been used in attempts to locate them. There is a lack of information on the use of magnetics, and the magnetometer, and some of this un-published data should be supplied.

Formation of reefs may be studied in many parts of the world today. In their tropic or semi-tropical surroundings they swarm with myriad life, and are under constant charging of ceaseless wave action, pounding surf, typhoons and other storms of the tropical seas. There are small and great reefs in the process of forming today, and we have but to examine them to have a clear conception of the reefs of the past.

On a magnetometer survey it is not an easy matter to interpret a reef. On the other hand it is not difficult to find what might be a reef. The close detailed outline, the anomaly, and knowledge of sub-surface geology are the required factors, plus the field technique of using the sedimentary rocks as datum.

Magnetometer surveys in Canada in 1939-40 and '41 brought out certain dome-like structures that were mostly unsymmetrical. It was not until later that these were interpreted as reefs, although the depths as calculated placed the datum beds at the depths at which Devonian-Silurian formations could be expected.

Later, the Marine pool in Illinois, and other pools in Illinois and nearby states were discovered, and surveys at least in detail or profile were conducted over known reefs that were producing. Thus pictures of surveys were obtained that could be used as criteria, for interpretation of other reef pictures.

The Siosi pool in southern Vigo County, Indiana, is a typical organic reef. Production is from the Devonian-Silurian formation at depths of 2180 to 2250 ft. Closure on the sides of the reef is more than 70 ft. It is not possible to conduct a magnetometer survey across the crest of the reef, due to interference of the flow lines, electrical installations, etc., but a profile across the abandoned north part of the pool shows the distinct outline of the reef. The contour map using the top of the Devonian lime, and the magnetometer profile is shown as Fig. 1.

Four miles to the northeast the Prairie Creek pool is a much smaller and differently shaped reef.

Figs. 2 and 3 are both type "Horse Shoe Shaped" reefs typical of the atolls of the South Pacific today, and with the indentations, which must have been lagoons. One of these is in Indiana, and the one shown in Fig. 3 in Kentucky. Of more than passing interest is the direction or side of the reef on which the lagoon most generally occurs. It is away from the basin, thus up dip. Fig. 2 has had one test well, and although it had a show it did not make a producer. The other is not drilled at this time.

Fig. 4 is a faulted reef, on which there is shallow production. The Devonian has not been drilled. Evidence of the structural forces, and the resultant

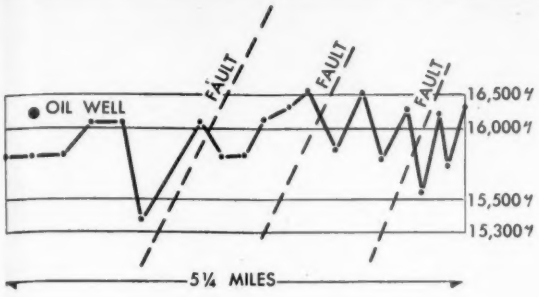

FIG. 10.

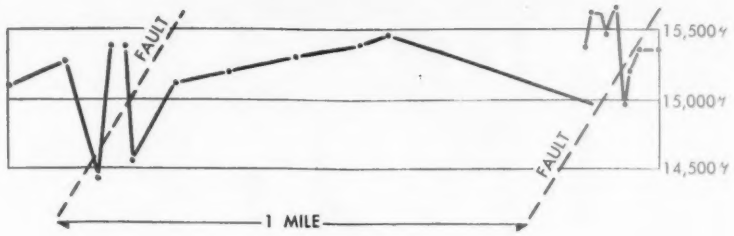

FIG. 11.

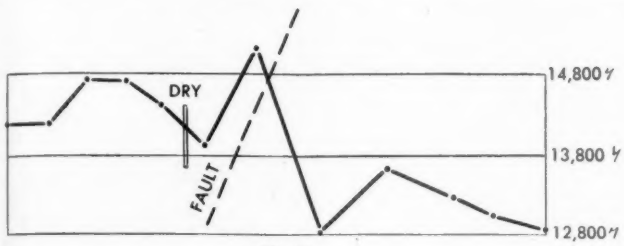

FIG. 12.

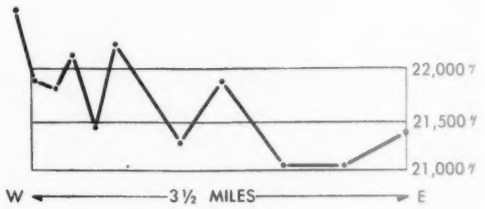

FIG. 13.

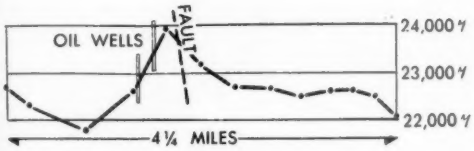

FIG. 14.

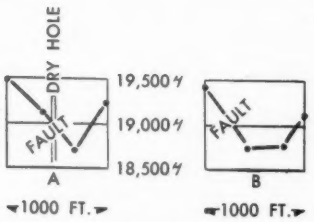

FIG. 15.

compression is to be noted on the southwestern side of the fault.

Fig. 5 shows a reef structure in Illinois producing from an upper shallow pay. In this instance, very large wells were made in the McClosky. After water flooding, it will be drilled to the deep pay. The large terrace to the north, and on the 15,400 gamma contour, is to some extent typical of areas around reefs, and could have been shallow areas of the sea at the time of the reef formation.

A large un-drilled reef in Canada is shown in Fig. 6. Here again is the lagoon, and it is also away from the basinward dip. This has not been drilled, and is a good prospect.

A Devonian reef in Michigan, Fig. 7, because of its location is ideal for a magnetometer survey, as the topography is almost flat. One or more small wells have been drilled.

Fig. 8 is a very shallow area for Devonian, depth being only about 1400 ft. Therefore this reef extends down into the Trenton. The Devonian has had one test well as shown. Perhaps another, better situated, would produce. A very large part of the structure is producing from a very shallow sand in the Pennsylvanian.

Faults

Faults have been mentioned, and as they are so closely associated not only with reefs, but many of the other oil bearing structures, it would be well to examine a few of them. It can no doubt be said without any fear of contradiction that the magnetometer is the peer of all geophysical instruments in the outlining and location of faults. So many of the present structures known as stratigraphic traps, shale, and sand pinch outs, etc., are so closely governed by the condition of the faulted area, that more and more is the very close detail use being made of this useful exploratory tool.

Fig. 9 is a structure contoured with magnetometer between two faults. The magnetometer location struck, the pay is very shallow, less than 1700 ft. Initial wells came in for large production, and one is still producing over 275 bbl per day, after nearly three years. The two faults are typical of this part of the Indiana-Illinois basin.

Another faulted area that has no doubt been a large contributory factor in pooling production is illustrated in Fig. 10. This is near the Mt. Carmel area in Illinois. Large pools are all around the faults on both sides, at varying distances, and under varying structural conditions.

A typical dome between two faults is shown in Fig. 11. This prolific structure initially produced from 600 ft. Later drilling has shown a second horizon above 2000 ft.

The profile in Fig. 12 clearly shows that if the survey had been conducted prior to drilling, the dry hole would not have been dug. This is a part of the Shawneetown Fault. It is a large structural feature in Illinois, and Kentucky, and extends on to the east for a great distance, where it is known as the Rough Creek, Paintsville, Warfield, Chestnut Ridge Fault.

Near Cotulla, Texas, is a large fault, Fig. 13. It was not surveyed in detail. Area of the magnetometer survey was not nearby. It is of great interest, due to its width, and structural possibilities.

Another Texas Fault, Fig. 14, is how-

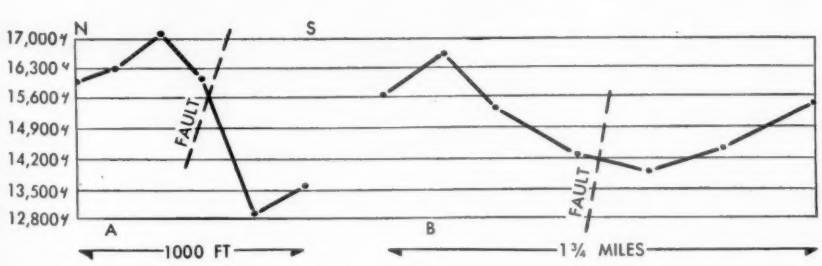

FIG. 16.

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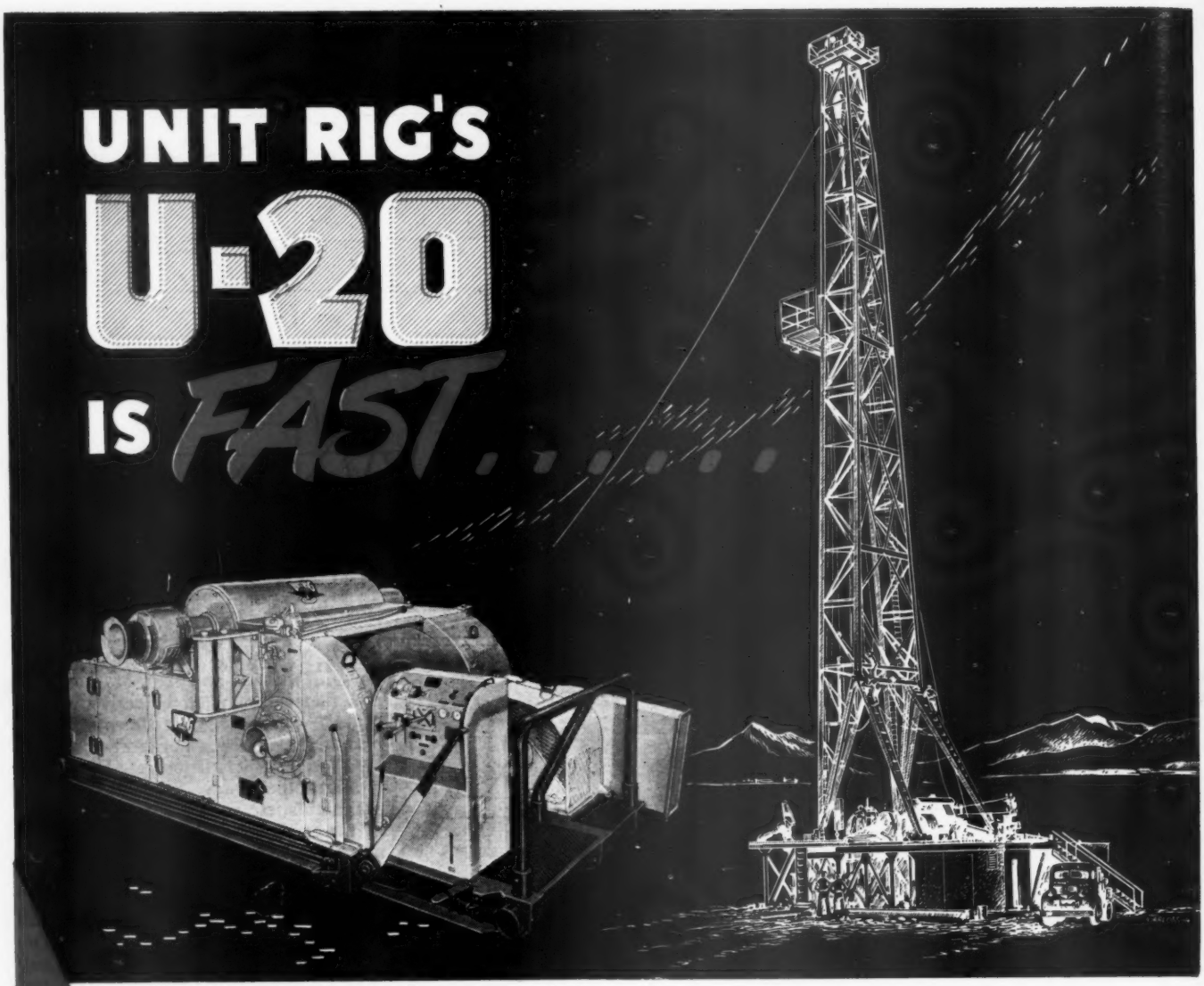

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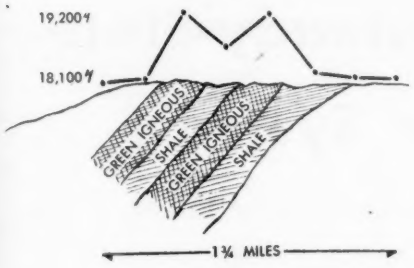

FIG. 17

ever, not far from Victoria. There is a shut-off of a producing area on the north side, as shown. It would be a good risk to drill on the south side, as there are sizable structural possibilities to the south across the fault.

On a survey in Oklahoma, Fig. 15, it was found that a previous test well had been drilled on the fault as shown by "A." This was on a high as found by another survey using a different geophysical method. The magnetometer location for a test well was on structure, but due to a later office error the second well was drilled so near the same fault, that it was also a dry hole. "B" shows the same fault near the second well.

A and B are purely of a scientific nature, Fig. 16, "A" being a known fault the Honey Creek, in Kentucky. B is an unknown, but reasonably certain fault, known as the Dripping Spring Escarpment. The two profiles are so nearly alike, there is small doubt but that the escarpment is a fault. The faulted rocks limestones are exposed in the valley, and are probably Glen Dean lime faulted against the Ste. Genevieve limestone.

Returning as it were, to ore prospecting, Fig. 17, the dyke as found in St. Miguel County, New Mexico, is well illustrative of this kind of a magnetometer survey. A test well for oil had been drilled nearby, the dyke at depth goes in the direction of the well. It was dry, of course. It is odd that safeguards against these eventualities are not taken.

The above surveys are contoured in gammas. The gamma is a magnetic unit of measurement, 100,000th part of an oersted, another unit. By the use of this unit, no anomaly is too small for measurement. Also base stations can be, if desired, checked, with those established by the Coast and Geodetic Survey.

The gamma can be compared to feet if two or more wells have been drilled not too far away, and if there is a difference in their geological tops of even a few feet. Gamma value readings can be taken near the wells, and this difference can be compared to the foot difference in the geological tops.

If the wells are separated by a fault, however, it would be well to take this into consideration, and obtain all further data possible. * * *

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A Practical Treatment of Nonsteady-State Flow Problems in Reservoir Systems

Part 3 (Appendix) Practical information is presented in the form of tables, definitions, and a complete resume of the Hurst-van Everdingen equations

ANGELOS T. CHATAS*

Definitions

1. *Annulus Problem.* The determination of the flowing bottom-hole pressure history of a flowing well, undergoing a flow test, that produces through tubing at a constant surface-rate of production. During the test some of the oil comes from the pay formation, but some is also unloaded from the annulus between the tubing and casing.

2. *Annulus Volume Adjustment.* In the "annulus problem" the volume of fluid unloaded from the annulus per unit pressure drop per unit sand thickness. It may be expressed approximately by

$$\frac{\pi\,(r_c^2 - r_T^2)}{\rho_o g h}$$

which in dimensionless form becomes

$$C = \frac{r_c^2 - r_T^2}{2g\phi h\,\rho_o c_o r_w^2}$$

3. *Boundary Conditions.* The location of the interior and exterior boundaries and the specification of pressure and/or flow at these boundaries at a given instant of time.

4. *Boundary Variations.* The changes in the boundary conditions of a reservoir system undergoing exploitation.

5. *Continuous Succession of Steady States.* A method of solving flow problems in a reservoir system that suffers boundary variations but fulfills instantaneous steady-state conditions. The history of such a system is divided into an appropriate number of stages, each of which is treated by steady-state analysis.

6. *Dimensionless Time Ratio.* The dimensionless ratio defined by the following relations:

Radial System

$$t = \frac{k\,\theta}{\phi\,\mu\,c_t r_w^2}$$

Linear System

$$t = \frac{k\theta}{\Phi\,\mu\,c_t\,x_c^2} = \frac{K\theta}{\varphi M C_t}$$

7. *Fluid-Influx Terms.* Terms that appear in the Hurst-van Everdingen equation which treats the "pressure case." Such a term, denoted by $q(t)$, is a dimensionless, numerical quantity representing the total volume of fluid per unit thickness that passes the interior boundary of a reservoir system over the time span $t = t_M - t_1$, which is caused by a unit pressure drop at this boundary at time t_1.

8. *Infinite Reservoir System.* A reservoir system analyzed over a period of time during which the presence of an exterior boundary is not felt.

9. *Linear Reservoir System.* A system defined by two parallel planes, which serve as boundaries, over which pressure and flow are specified according to prescribed conditions, and whose physical properties of interest vary only with the perpendicular distance x between the two planes.

10. *Nonsteady-State Flow.* In reservoir systems undergoing exploitation, fluid flow that is characterized predominately by time variations and necessitates the formal introduction of time as an explicit variable in the basic flow equations.

11. *Oil Field Equivalent.* An oil field lumped together such that its outer limits serve as the interior boundary of a reservoir system, with a pressure equal to the average oil field pressure, and with a flux equal to the sum of the fluxes of the individual wells.

12. *Pressure Case.* In the analysis of a reservoir system the situation that presumes knowledge of the pressure history and predicts the cumulative fluid influx.

13. *Pressure Change Terms.* Terms that appear in the Hurst-van Everdingen equation which treats the "rate case." Such a term, denoted by $p(t)$, is a dimensionless, numerical quantity representing the change in pressure at the interior boundary of a reservoir system over the time span $t = t_M - t_1$, which is caused by a unit rate of production per unit thickness at time t_1.

14. *Pressure Correction Terms.* Terms that appear in the Hurst-van Evendingen equation which treats the "annulus problem." Such a term, denoted by $p'(t)$, is a diminsionless numerical quantity representing the total pressure drop in the well bore, which is caused by a unit rate of production at the surface and is corrected for the unloading of fluid from the annulus.

15. *Radial Reservoir System.* A system defined by two concentric circular cylinders, which serve as boundaries, over which pressure and flow are specified according to prescribed conditions, and whose physical properties of interest vary only with the distance r from the axis of symmetry.

16. *Rate Case.* In the analysis of a reservoir system the situation that presumes knowledge of the production or fluid-influx rate history and predicts the cumulative pressure drop for a reservoir at its interior boundary.

17. *Steady-State Flow.* In reservoir systems undergoing exploitation, fluid flow whose time variations are insignificant, and, which permit the formal neglect of time as an explicit variable in the basic flow equations.

18. *Time of Readjustment.* The approximate time required for the readjustment of the internal pressure distribution in a reservoir system to a steady-state distribution when pressure variations occur at the boundaries. For radial systems this time is given by

$$\theta_R = \frac{\phi c_t r_e^2}{4\,k/\mu}$$

while for linear systems it is

TABLE 1. Infinite radial system — Rate case.

Dimensionless time t	Pressure change p(t)	Dimensionless time t	Pressure change p(t)	Dimensionless time t	Pressure change p(t)	Dimensionless time t	Pressure change p(t)
0	0	.06	.2500	3.0	1.1665	150.0	2.9212
.005	.0250	.07	.2680	4.0	1.2750	200.0	3.0636
.001	.0352	.08	.2845	5.0	1.3625	250.0	3.1726
.002	.0495	.09	.2999	6.0	1.4362	300.0	3.2630
.003	.0603	.1	.3144	7.0	1.4997	350.0	3.3394
.004	.0694	.15	.3750	8.0	1.5557	400.0	3.4057
.005	.0774	.2	.4241	9.0	1.6057	450.0	3.4641
.006	.0845	.3	.5024	10.0	1.6509	500.0	3.5164
.007	.0911	.4	.5645	15.0	1.8294	550.0	3.5643
.008	.0971	.5	.6167	20.0	1.9601	600.0	3.6076
.009	.1028	.6	.6622	30.0	2.1470	650.0	3.6476
.01	.1081	.7	.7024	40.0	2.2824	700.0	3.6842
.015	.1312	.8	.7387	50.0	2.3884	750.0	3.7184
.02	.1503	.9	.7716	60.0	2.4758	800.0	3.7505
.025	.1669	1.0	.8019	70.0	2.5501	850.0	3.7805
.03	.1818	1.2	.8672	80.0	2.6147	900.0	3.8088
.04	.2077	1.4	.9160	90.0	2.6718	950.0	3.8355
.05	.2301	2.0	1.0195	100.0	2.7233	1000.0	3.8584

*Magnolia Petroleum Company.

$$\theta_R = \frac{\phi c_t x_M^2}{2\,k/\mu}$$

Hurst-Van Everdingen Equations

A. Radial Systems.

1. *Rate Case.* The rate case presumes knowledge of the production or fluid-influx rate history and predicts the cumulative pressure drop for a reservoir system at its interior boundary. This pressure drop is given by the simple algebraic equation

$$P_o - (r_w, \theta_M) = \frac{\mu}{2\pi kh}$$
$$\{Q(\theta_o)\, p(t_M) + [Q(\theta_1) - Q(\theta_o)] \times$$
$$p(t_M - t_1) + [Q(\theta_2) - Q(\theta_1)] \times$$
$$p(t_M - t_2) + \ldots + [Q(\theta_n) -$$
$$Q(\theta_{n-1})]\, p(t_M - t_n)\}$$

where it can be noted that P_o, μ, k, h, and $Q(\theta_1)$ are obtained from field data[t]. Thus, to obtain $P(r_w, \theta_M)$, the pressure at the interior boundary of a system at time θ_M, one need only further determine the pressure change terms $p(t)$ with $t = t_M - t_1$. These terms may be determined for the ensuing types of systems as follows:

Infinite system

$t < 0.01 \quad p(t) = 2\sqrt{t/\pi}$

$0.01 < t < 100$ see Fig. 1 or Table 1

$t > 100 \quad p(t) = 1/2(\ln t + 0.80907)$

Finite system with closed exterior boundary

$t < 0.01 \quad p(t) = 2\sqrt{t/\pi}$

$t > 0.01$ see Fig. 9 or Table 4

large t $\quad p(t) \approx \dfrac{(1/2 + 2t)}{[(r_e/r_w)^2 - 1]} -$

$$[3(r_e/r_w)^4 - 4(r_e/r_w)^4 \ln r_e/r_w - \frac{2(r_e/r_w)^2 - 1]}{4\,[(r_e/r_w)^2 - 1]}$$

Finite system with fixed constant pressure at exterior boundary

$t < 0.01 \quad p(t) = 2\sqrt{t/\pi}$

$t > 0.01$ see Figs. 10, 11, 12, and 13 or Table 5

large t $\quad p(t) \approx \ln r_e/r_w$

2. *Pressure Case.* The pressure case treats the inverse problem of determining the cumulative fluid influx, and presumes knowledge of the pressure history at the interior boundary of a reservoir system. This cumulative fluid influx is given by the similar algebraic equation

$$F_c(\theta_M) = 2\pi \phi c_t r_w^2 h$$
$$\{[P_o - P(\theta_1)]\, q(t_M) + [P(\theta_1) -$$
$$P(\theta_2)]\, q(t_M - t_1) + [P(\theta_2) -$$
$$P(\theta_3)]\, q(t_M - t_2) + \ldots +$$
$$[P(\theta_{n-1}) - P(\theta_n)]\, q(t_M - t_{n-1})\}$$

[t] Sometimes these quantities are not directly available from field data, and the empirical approach of examining and treating the past history of a system proves necessary for their determination.

TABLE 2. Infinite radial system — Pressure case.

Dimensionless time t	Fluid influx q(t)	Dimensionless time t	Fluid influx q(t)	Dimensionless time t	Fluid influx q(t)	Dimensionless time t	Fluid influx q(t)	Dimensionless time t	Fluid influx q(t)	Dimensionless time t	Fluid influx q(t)
0.00	0.000	79	35.697	455	150.249	1190	340.843	3250	816.090	35,000	6780.247
0.01	0.112	80	36.058	460	151.640	1200	343.308	3300	827.088	40,000	7650.096
0.05	0.278	81	36.418	465	153.029	1210	345.770	3350	838.067	50,000	9363.099
0.10	0.404	82	36.777	470	154.416	1220	348.230	3400	849.028	60,000	11,047.299
0.15	0.520	83	37.136	475	155.801	1225	349.460	3450	859.974	70,000	12,708.358
0.20	0.606	84	37.494	480	157.184	1230	350.688	3500	870.903	75,000	13,531.457
0.25	0.689	85	37.851	485	158.565	1240	353.144	3550	881.816	80,000	14,350.121
0.30	0.758	86	38.207	490	159.945	1250	355.597	3600	892.712	90,000	15,975.389
0.40	0.898	87	38.563	495	161.322	1260	358.048	3650	903.594	100,000	17,586.284
0.50	1.020	88	38.919	500	162.698	1270	360.496	3700	914.459	125,000	21,560.732
0.60	1.140	89	39.272	510	165.444	1275	361.720	3750	925.309	$1.5(10)^5$	$2.538(10)^4$
0.70	1.251	90	39.626	520	168.183	1280	362.942	3800	936.144	2.0 "	3.308 "
0.80	1.359	91	39.979	525	169.549	1290	365.386	3850	946.966	2.5 "	4.066 "
0.90	1.469	92	40.331	530	170.914	1300	367.828	3900	957.773	3.0 "	4.817 "
1	1.569	93	40.684	540	173.639	1310	370.267	3950	968.566	4.0 "	6.267 "
2	2.447	94	41.034	550	176.357	1320	372.704	4000	979.344	5.0 "	7.699 "
3	3.202	95	41.385	560	179.069	1325	373.922	4050	990.108	6.0 "	9.113 "
4	3.893	96	41.735	570	181.774	1330	375.139	4100	1000.858	7.0 "	$1.051(10)^5$
5	4.539	97	42.084	575	183.124	1340	377.572	4150	1011.595	8.0 "	1.189 "
6	5.153	98	42.433	580	184.473	1350	380.003	4200	1022.318	9.0 "	1.326 "
7	5.743	99	42.781	590	187.166	1360	382.432	4250	1033.028	$1.0(10)^6$	1.462 "
8	6.314	100	43.129	600	189.852	1370	384.859	4300	1043.724	1.5 "	2.126 "
9	6.869	105	44.858	610	192.533	1375	386.070	4350	1054.409	2.0 "	2.781 "
10	7.411	110	46.574	620	195.208	1380	387.283	4400	1065.082	2.5 "	3.427 "
11	7.940	115	48.277	625	196.544	1390	389.705	4450	1075.743	3.0 "	4.064 "
12	8.457	120	49.968	630	197.878	1400	392.125	4500	1086.390	4.0 "	5.313 "
13	8.964	125	51.648	640	200.542	1410	394.543	4550	1097.024	5.0 "	6.544 "
14	9.461	130	53.317	650	203.201	1420	396.959	4600	1107.646	6.0 "	7.761 "
15	9.949	135	54.976	660	205.854	1425	398.167	4650	1118.257	7.0 "	8.965 "
16	10.434	140	56.625	670	208.502	1430	399.373	4700	1128.854	8.0 "	$1.016(10)^6$
17	10.913	145	58.265	675	209.825	1440	401.786	4750	1139.439	9.0 "	1.134 "
18	11.386	150	59.895	680	211.145	1450	404.197	4800	1150.012	$1.0(10)^7$	1.252 "
19	11.855	155	61.517	690	213.784	1460	406.606	4850	1160.574	1.5 "	1.828 "
20	12.319	160	63.131	700	216.417	1470	409.013	4900	1171.125	2.0 "	2.398 "
21	12.778	165	64.737	710	219.046	1475	410.214	4950	1181.666	2.5 "	2.961 "
22	13.233	170	66.336	720	221.670	1480	411.418	5000	1192.198	3.0 "	3.517 "
23	13.684	175	67.928	725	222.980	1490	413.820	5100	1213.222	4.0 "	4.610 "
24	14.131	180	69.512	730	224.289	1500	416.220	5200	1234.203	5.0 "	5.689 "
25	14.573	185	71.090	740	226.904	1525	422.214	5300	1255.141	6.0 "	6.758 "
26	15.013	190	72.661	750	229.514	1550	428.196	5400	1276.037	7.0 "	7.816 "
27	15.450	195	74.226	760	232.120	1575	434.168	5500	1296.893	8.0 "	8.866 "
28	15.883	200	75.785	770	234.721	1600	440.128	5600	1317.709	9.0 "	9.911 "
29	16.313	205	77.338	775	236.020	1625	446.077	5700	1338.486	$1.0(10)^8$	$1.095(10)^7$
30	16.742	210	78.886	780	237.318	1650	452.016	5800	1359.225	1.5 "	1.604 "
31	17.167	215	80.428	790	239.912	1675	457.945	5900	1379.927	2.0 "	2.108 "
32	17.590	220	81.965	800	242.501	1700	463.863	6000	1400.593	2.5 "	2.607 "
33	18.011	225	83.497	810	245.086	1725	469.771	6100	1421.224	3.0 "	3.100 "
34	18.429	230	85.023	820	247.668	1750	475.669	6200	1441.820	4.0 "	4.071 "
35	18.845	235	86.545	825	248.957	1775	481.558	6300	1462.383	5.0 "	5.032 "
36	19.259	240	88.062	830	250.245	1800	487.437	6400	1482.912	6.0 "	5.984 "
37	19.671	245	89.575	840	252.819	1825	493.307	6500	1503.408	7.0 "	6.928 "
38	20.080	250	91.084	850	255.388	1850	499.167	6600	1523.872	8.0 "	7.865 "
39	20.488	255	92.589	860	257.953	1875	505.019	6700	1544.305	9.0 "	8.797 "
40	20.894	260	94.090	870	260.515	1900	510.861	6800	1564.706	$1.0(10)^9$	9.725 "
41	21.298	265	95.588	875	261.795	1925	516.695	6900	1585.077	1.5 "	$1.429(10)^8$
42	21.701	270	97.081	880	263.073	1950	522.520	7000	1605.418	2.0 "	1.880 "
43	22.101	275	98.571	890	265.629	1975	528.337	7100	1625.729	2.5 "	2.328 "
44	22.500	280	100.057	900	268.181	2000	534.145	7200	1646.011	3.0 "	2.771 "
45	22.897	285	101.540	910	270.729	2025	539.945	7300	1666.265	4.0 "	3.645 "
46	23.291	290	103.019	920	273.274	2050	545.737	7400	1686.490	5.0 "	4.510 "
47	23.684	295	104.495	925	274.545	2075	551.522	7500	1706.688	6.0 "	5.368 "
48	24.076	300	105.968	930	275.815	2100	557.299	7600	1726.859	7.0 "	6.220 "
49	24.466	305	107.437	940	278.353	2125	563.068	7700	1747.002	8.0 "	7.066 "
50	24.855	310	108.904	950	280.888	2150	568.830	7800	1767.120	9.0 "	7.909 "
51	25.244	315	110.367	960	283.420	2175	574.585	7900	1787.212	$1.0(10)^{10}$	8.747 "
52	25.633	320	111.827	970	285.948	2200	580.332	8000	1807.278	1.5 "	$1.288(10)^9$
53	26.020	325	113.284	975	287.211	2225	586.072	8100	1827.319	2.0 "	1.697 "
54	26.406	330	114.738	980	288.473	2250	591.806	8200	1847.336	2.5 "	2.103 "
55	26.791	335	116.189	990	290.995	2275	597.532	8300	1867.329	3.0 "	2.505 "
56	27.174	340	117.638	1000	293.514	2300	603.252	8400	1887.298	4.0 "	3.299 "
57	27.555	345	119.083	1010	296.030	2325	608.965	8500	1907.243	5.0 "	4.087 "
58	27.935	350	120.526	1020	298.543	2350	614.672	8600	1927.166	6.0 "	4.868 "
59	28.314	355	121.966	1025	299.799	2375	620.372	8700	1947.065	7.0 "	5.643 "
60	28.691	360	123.403	1030	301.053	2400	626.066	8800	1966.942	8.0 "	6.414 "
61	29.068	365	124.838	1040	303.560	2425	631.755	8900	1986.796	9.0 "	7.183 "
62	29.443	370	126.270	1050	306.065	2450	637.437	9000	2006.628	$1.0(10)^{11}$	7.948 "
63	29.818	375	127.699	1060	308.567	2475	643.113	9100	2026.438	1.5 "	$1.17(10)^{10}$
64	30.192	380	129.126	1070	311.066	2500	648.781	9200	2046.227	2.0 "	1.55 "
65	30.565	385	130.550	1075	312.314	2550	660.093	9300	2065.996	2.5 "	1.92 "
66	30.937	390	131.972	1080	313.562	2600	671.379	9400	2085.744	3.0 "	2.29 "
67	31.308	395	133.391	1090	316.055	2650	682.640	9500	2105.473	4.0 "	3.02 "
68	31.679	400	134.808	1100	318.545	2700	693.877	9600	2125.184	5.0 "	3.75 "
69	32.048	405	136.223	1110	321.032	2750	705.090	9700	2144.878	6.0 "	4.47 "
70	32.417	410	137.635	1120	323.517	2800	716.280	9800	2164.555	7.0 "	5.19 "
71	32.785	415	139.045	1125	324.760	2850	727.449	9900	2184.216	8.0 "	5.89 "
72	33.151	420	140.453	1130	326.000	2900	738.598	10,000	2203.861	9.0 "	6.58 "
73	33.517	425	141.859	1140	328.480	2950	749.725	12,500	2688.967	$1.0(10)^{12}$	7.28 "
74	33.883	430	143.262	1150	330.958	3000	760.833	15,000	3164.780	1.5 "	$1.08(10)^{11}$
75	34.247	435	144.664	1160	333.433	3050	771.922	17,500	3633.368	2.0 "	1.42 "
76	34.611	440	146.064	1170	335.906	3100	782.992	20,000	4095.800		
77	34.974	445	147.461	1175	337.142	3150	794.042	25,000	5005.726		
78	35.336	450	148.856	1180	338.376	3200	805.075	30,000	5899.508		

where again all the terms on the right hand side of the equation, except the fluid-influx terms $q(t)$, may be obtained from field data[t]. The fluid-influx terms may be determined similarly as follows:

Infinite system

$t < 0.01 \quad q(t) = 2\sqrt{t/\pi}$

$t > 0.01$ See Figs. 2, 3, and 4 or Table 2.

Finite system with closed exterior boundary

$t < 0.01$ See $q(t) = 2\sqrt{t/\pi}$

$t > 0.01$ See Figs. 5, 6, 7, and 8 or Table 3

large t $\quad q(t) \approx [(r_e/r_w)^2 - 1]/2$

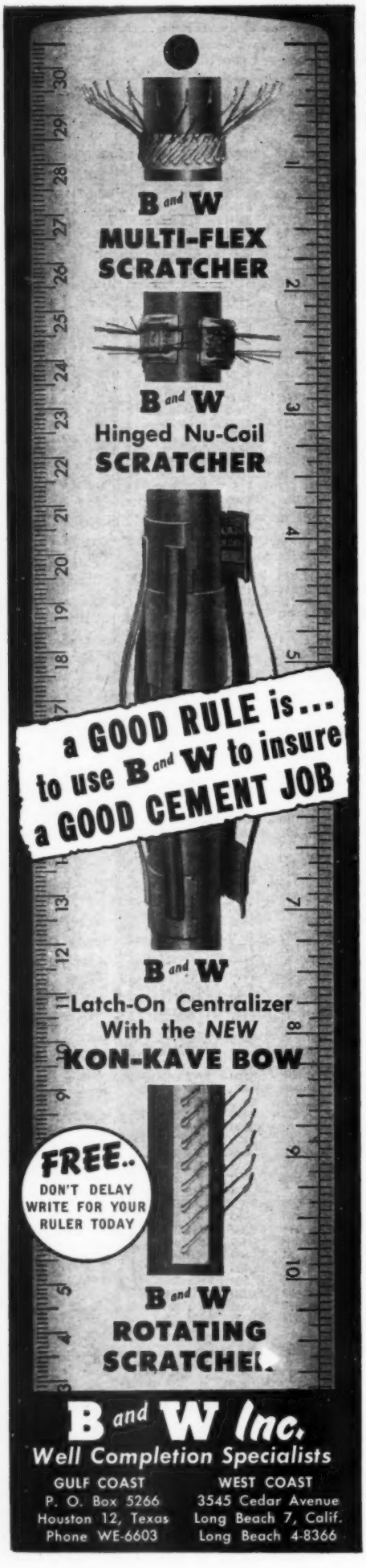

TABLE 3. Finite radial system with closed exterior boundary—Pressure case.

re/rw=1.5		re/rw=2.0		re/rw=2.5		re/rw=3.0		re/rw=3.5		re/rw=4.0		re/rw=4.5	
Dimensionless time t	Fluid influx q(t)	Dimensionless time t	Fluid influx q(t)	Dimensionless time t	Fluid influx q(t)	Dimensionless time t	Fluid influx q(t)	Dimensionless time t	Fluid influx q(t)	Dimensionless time t	Fluid influx q(t)	Dimensionless time t	Fluid influx q(t)
$5.0(10)^{-1}$	0.276	$5.0(10)^{-2}$	0.278	$1.0(10)^{-1}$	0.408	$3.0(10)^{-1}$	0.755	1.00	1.571	2.00	2.442	2.5	2.835
6.0 "	0.304	7.5 "	0.345	1.5 "	0.509	4.0 "	0.895	1.20	1.761	2.20	2.598	3.0	3.196
7.0 "	0.330	$1.0(10)^{-1}$	0.404	2.0 "	0.599	5.0 "	1.023	1.40	1.940	2.40	2.748	3.5	3.537
8.0 "	0.354	1.25 "	0.458	2.5 "	0.681	6.0 "	1.143	1.60	2.111	2.60	2.893	4.0	3.859
9.0	0.375	1.50 "	0.507	3.0 "	0.758	7.0 "	1.256	1.80	2.273	2.80	3.034	4.5	4.165
$1.0(10)^{-1}$	0.395	1.75 "	0.553	3.5 "	0.829	8.0 "	1.363	2.00	2.427	3.00	3.170	5.0	4.454
1.1 "	0.414	2.00 "	0.597	4.0 "	0.897	9.0 "	1.465	2.20	2.574	3.25	3.334	5.5	4.727
1.2 "	0.431	2.25 "	0.638	4.5 "	0.962	1.00	1.563	2.40	2.715	3.50	3.493	6.0	4.986
1.3 "	0.446	2.50 "	0.678	5.0 "	1.024	1.25	1.791	2.60	2.849	3.75	3.645	6.5	5.231
1.4 "	0.461	2.75 "	0.715	5.5 "	1.083	1.50	1.997	2.80	2.976	4.00	3.792	7.0	5.464
1.5 "	0.474	3.00 "	0.751	6.0 "	1.140	1.75	2.184	3.00	3.098	4.25	3.932	7.5	5.684
1.6 "	0.486	3.25 "	0.785	6.5 "	1.195	2.00	2.353	3.25	3.242	4.50	4.068	8.0	5.892
1.7 "	0.497	3.50 "	0.817	7.0 "	1.248	2.25	2.507	3.50	3.379	4.75	4.198	8.5	6.089
1.8 "	0.507	3.75 "	0.848	7.5 "	1.299	2.50	2.646	3.75	3.507	5.00	4.323	9.0	6.276
1.9 "	0.517	4.00 "	0.877	8.0 "	1.348	2.75	2.772	4.00	3.628	5.50	4.560	9.5	6.453
2.0 "	0.525	4.25 "	0.905	8.5 "	1.395	3.00	2.886	4.25	3.742	6.00	4.779	10	6.621
2.1 "	0.533	4.50 "	0.932	9.0 "	1.440	3.25	2.990	4.50	3.850	6.50	4.982	11	6.930
2.2 "	0.541	4.75 "	0.958	9.5 "	1.484	3.50	3.084	4.75	3.951	7.00	5.169	12	7.208
2.3 "	0.548	5.00 "	0.983	1.0	1.526	3.75	3.170	5.00	4.047	7.50	5.343	13	7.457
2.4 "	0.554	5.50 "	1.028	1.1	1.605	4.00	3.247	5.50	4.222	8.00	5.504	14	7.680
2.5 "	0.559	6.00 "	1.070	1.2	1.679	4.25	3.317	6.00	4.378	8.50	5.653	15	7.880
2.6 "	0.565	6.50 "	1.108	1.3	1.747	4.50	3.381	6.50	4.516	9.00	5.790	16	8.060
2.8 "	0.574	7.00 "	1.143	1.4	1.811	4.75	3.439	7.00	4.639	9.50	5.917	18	8.365
3.0 "	0.582	7.50 "	1.174	1.5	1.870	5.00	3.491	7.50	4.749	10	6.035	20	8.611
3.2 "	0.588	8.00 "	1.203	1.6	1.924	5.50	3.581	8.00	4.846	11	6.246	22	8.809
3.4 "	0.594	9.00 "	1.253	1.7	1.975	6.00	3.656	8.50	4.932	12	6.425	24	8.968
3.6 "	0.599	1.00	1.295	1.8	2.022	6.50	3.717	9.00	5.009	13	6.580	26	9.097
3.8 "	0.603	1.1	1.330	2.0	2.106	7.00	3.767	9.50	5.078	14	6.712	28	9.200
4.0 "	0.606	1.2	1.358	2.2	2.178	7.50	3.809	10.00	5.138	15	6.825	30	9.283
4.5 "	0.613	1.3	1.382	2.4	2.241	8.00	3.843	11	5.241	16	6.922	34	9.404
5.0 "	0.617	1.4	1.402	2.6	2.294	9.00	3.894	12	5.321	17	7.004	38	9.481
6.0 "	0.621	1.6	1.432	2.8	2.340	10.00	3.928	13	5.385	18	7.076	42	9.532
7.0 "	0.623	1.7	1.444	3.0	2.380	11.00	3.951	14	5.435	20	7.189	46	9.565
8.0 "	0.624	1.8	1.453	3.4	2.444	12.00	3.967	15	5.476	22	7.272	50	9.586
		2.0	1.468	3.8	2.491	14.00	3.985	16	5.506	24	7.332	60	9.612
		2.5	1.487	4.2	2.525	16.00	3.993	17	5.531	26	7.377	70	9.621
		3.0	1.495	4.6	2.551	18.00	3.997	18	5.551	30	7.434	80	9.623
		4.0	1.499	5.0	2.570	20.00	3.999	20	5.579	34	7.464	90	9.624
		5.0	1.500	6.0	2.599	22.00	3.999	25	5.611	38	7.481	100	9.625
				7.0	2.613	24.00	4.000	30	5.621	42	7.490		
				8.0	2.619			35	5.624	46	7.494		
				9.0	2.622			40	5.625	50	7.497		
				10.0	2.624								

re/rw=5.0		re/rw=6.0		re/rw=7.0		re/rw=8.0		re/rw=9.0		re/rw=10.0	
Dimensionless time t	Fluid influx q(t)	Dimensionless time t	Fluid influx q(t)	Dimensionless time t	Fluid influx q(t)	Dimensionless time t	Fluid influx q(t)	Dimensionless time t	Fluid influx q(t)	Dimensionless time t	Fluid influx q(t)
3.0	3.195	6.0	5.148	9.00	6.861	9	6.861	10	7.417	15	9.965
3.5	3.542	6.5	5.440	9.50	7.127	10	7.398	15	9.945	20	12.32
4.0	3.875	7.0	5.724	10	7.389	11	7.920	20	12.26	22	13.22
4.5	4.193	7.5	6.002	11	7.902	12	8.431	22	13.13	24	14.09
5.0	4.499	8.0	6.273	12	8.397	13	8.930	24	13.98	26	14.95
5.5	4.792	8.5	6.537	13	8.876	14	9.418	26	14.79	28	15.78
6.0	5.074	9.0	6.795	14	9.341	15	9.895	28	15.59	30	16.59
6.5	5.345	9.5	7.047	15	9.791	16	10.361	30	16.35	32	17.38
7.0	5.605	10.0	7.293	16	10.23	17	10.82	32	17.10	34	18.16
7.5	5.854	10.5	7.533	17	10.65	18	11.26	34	17.82	36	18.91
8.0	6.094	11	7.767	18	11.06	19	11.70	36	18.52	38	19.65
8.5	6.325	12	8.220	19	11.46	20	12.13	38	19.19	40	20.37
9.0	6.547	13	8.651	20	11.85	22	12.95	40	19.85	42	21.07
9.5	6.760	14	9.063	22	12.58	24	13.74	42	20.48	44	21.76
10	6.965	15	9.456	24	13.27	26	14.50	44	21.09	46	22.42
11	7.350	16	9.829	26	13.92	28	15.23	46	21.69	48	23.07
12	7.706	17	10.19	28	14.53	30	15.92	48	22.26	50	23.71
13	8.035	18	10.53	30	15.11	34	17.22	50	22.82	52	24.33
14	8.339	19	10.85	35	16.39	38	18.41	52	23.36	54	24.94
15	8.620	20	11.16	40	17.49	40	18.97	54	23.89	56	25.53
16	8.879	22	11.74	45	18.43	45	20.26	56	24.39	58	26.11
18	9.338	24	12.26	50	19.24	50	21.42	58	24.88	60	26.67
20	9.731	25	12.50	60	20.51	55	22.46	60	25.36	65	28.02
22	10.07	31	13.74	70	21.45	60	23.40	65	26.48	70	29.29
24	10.35	35	14.40	80	22.13	70	24.98	70	27.52	75	30.49
26	10.59	39	14.93	90	22.63	80	26.26	75	28.48	80	31.61
28	10.80	51	16.05	100	23.00	90	27.28	80	29.36	85	32.67
30	10.98	60	16.56	120	23.47	100	28.11	85	30.18	90	33.66
34	11.26	70	16.91	140	23.71	120	29.31	90	30.93	95	34.60
38	11.46	80	17.14	160	23.85	140	30.08	95	31.63	100	35.48
42	11.61	90	17.27	180	23.92	160	30.52	100	32.27	120	38.51
46	11.71	100	17.36	200	23.96	180	30.91	120	34.39	140	40.89
50	11.79	110	17.41	500	24.00	200	31.12	140	35.92	160	42.75
60	11.91	120	17.45			240	31.34	160	37.04	180	44.21
70	11.96	130	17.46			280	31.43	180	37.85	200	45.36
80	11.98	140	17.48			320	31.47	200	38.44	240	46.95
90	11.99	150	17.49			360	31.49	240	39.17	280	47.94
100	12.00	160	17.49			400	31.50	280	39.56	320	48.54
120	12.00	180	17.50			500	31.50	320	39.77	360	48.91
		200	17.50					360	39.88	400	49.14
		220	17.50					400	39.94	440	49.28
								440	39.97	480	49.36
								480	39.98		

3. *Rate of Fluid Influx.* The rate of fluid influx has been presented as a function of the fluid-influx terms and, therefore, is a modification of the "pressure case." Thus the rate of fluid-influx at the interior boundary of a radial reservoir system is given at time θ_M by the algebraic equation

$$Q(\theta_M) = 2\pi\phi c_t r_w^2 h \left\{ [P_o - P(\theta_1)] \frac{[q(t_M) - q(t_M - t_1)]}{\theta_1} + [P(\theta_1) - P(\theta_2)] \right.$$

TABLE 4. Finite radial system with closed exterior boundary—Rate case.

re/rw=1.5		re/rw=2.0		re/rw=2.5		re/rw=3.0		re/rw=3.5		re/rw=4.0	
Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change
t	p(t)	t	p(t)	t	p(t)	t	(pt)	t	p(t)	t	p(t)
$6.0(10)^{-2}$	0.251	$2.2(10)^{-1}$	0.443	$4.0(10)^{-1}$	0.565	$5.2(10)^{-1}$	0.627	1.0	0.802	1.5	0.927
8.0 "	0.288	2.4 "	0.459	4.2 "	0.576	5.4 "	0.636	1.1	0.830	1.6	0.948
$1.0(10)^{-1}$	0.322	2.6 "	0.476	4.4 "	0.587	5.6 "	0.645	1.2	0.857	1.7	0.968
1.2 "	0.355	2.8 "	0.492	4.6 "	0.598	6.0 "	0.662	1.3	0.882	1.8	0.988
1.4 "	0.387	3.0 "	0.507	4.8 "	0.608	6.5 "	0.683	1.4	0.906	1.9	1.007
1.6 "	0.420	3.2 "	0.522	5.0 "	0.618	7.0 "	0.703	1.5	0.929	2.0	1.025
1.8 "	0.452	3.4 "	0.536	5.2 "	0.628	7.5 "	0.721	1.6	0.951	2.2	1.059
2.0 "	0.484	3.6 "	0.551	5.4 "	0.638	8.0 "	0.740	1.7	0.973	2.4	1.092
2.2 "	0.516	3.8 "	0.565	5.6 "	0.647	8.5 "	0.758	1.8	0.994	2.6	1.123
2.4 "	0.548	4.0 "	0.579	5.8 "	0.657	9.0 "	0.776	1.9	1.014	2.8	1.154
2.6 "	0.580	4.2 "	0.593	6.0 "	0.666	9.5 "	0.791	2.0	1.034	3.0	1.184
2.8 "	0.612	4.4 "	0.607	6.5 "	0.688	1.0	0.806	2.25	1.083	3.5	1.255
3.0 "	0.644	4.6 "	0.621	7.0 "	0.710	1.2	0.865	2.50	1.130	4.0	1.324
3.5 "	0.724	4.8 "	0.634	7.5 "	0.731	1.4	0.920	2.75	1.176	4.5	1.392
4.0 "	0.804	5.0 "	0.648	8.0 "	0.752	1.6	0.973	3.0	1.221	5.0	1.460
4.5 "	0.884	6.0 "	0.715	8.5 "	0.772	2.0	1.076	4.0	1.401	5.5	1.527
5.0 "	0.964	7.0 "	0.782	9.0 "	0.792	3.0	1.328	5.0	1.579	6.0	1.594
5.5 "	1.044	8.0 "	0.849	9.5 "	0.812	4.0	1.578	6.0	1.757	6.5	1.660
6.0 "	1.124	9.0 "	0.915	1.0	0.832	5.0	1.828			7.0	1.727
		1.0	0.982	2.0	1.215					8.0	1.861
		2.0	1.649	3.0	1.596					9.0	1.994
		3.0	2.316	4.0	1.977					10.0	2.127
		5.0	3.649	5.0	2.358						

re/rw=4.5		re/rw=5.0		re/rw=6.0		re/rw=7.0		re/rw=8.0		re/rw=9.0		re/rw=10.0	
Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change
t	p(t)	t	p(t)	t	p(t)	t	p(t)	t	p(t)	t	p(t)	t	p(t)
2.0	1.023	3.0	1.167	4.0	1.275	6.0	1.436	8.0	1.556	10.0	1.651	12.0	1.732
2.1	1.040	3.1	1.180	4.5	1.322	6.5	1.470	8.5	1.582	10.5	1.673	12.5	1.750
2.2	1.056	3.2	1.192	5.0	1.364	7.0	1.501	9.0	1.607	11.0	1.693	13.0	1.768
2.3	1.072	3.3	1.204	5.5	1.404	7.5	1.531	9.5	1.631	11.5	1.713	13.5	1.784
2.4	1.087	3.4	1.215	6.0	1.441	8.0	1.559	10.0	1.653	12.0	1.732	14.0	1.801
2.5	1.102	3.5	1.227	6.5	1.477	8.5	1.586	10.5	1.675	12.5	1.750	14.5	1.817
2.6	1.116	3.6	1.238	7.0	1.511	9.0	1.613	11.0	1.697	13.0	1.768	15.0	1.832
2.7	1.130	3.7	1.249	7.5	1.544	9.5	1.638	11.5	1.717	13.5	1.786	15.5	1.847
2.8	1.144	3.8	1.259	8.0	1.576	10.0	1.663	12.0	1.737	14.0	1.803	16.0	1.862
2.9	1.158	3.9	1.270	8.5	1.607	11.0	1.711	12.5	1.757	14.5	1.819	17.0	1.890
3.0	1.171	4.0	1.281	9.0	1.638	12.0	1.757	13.0	1.776	15.0	1.835	18.0	1.917
3.2	1.197	4.2	1.301	9.5	1.668	13.0	1.810	13.5	1.795	15.5	1.851	19.0	1.943
3.4	1.222	4.4	1.321	10.0	1.698	14.0	1.845	14.0	1.813	16.0	1.867	20.0	1.968
3.6	1.246	4.6	1.340	11.0	1.757	15.0	1.888	14.5	1.831	17.0	1.897	22.0	2.017
3.8	1.269	4.8	1.360	12.0	1.815	16.0	1.931	15.0	1.849	18.0	1.926	24.0	2.063
4.0	1.292	5.0	1.378	13.0	1.873	17.0	1.974	17.0	1.919	19.0	1.955	26.0	2.108
4.5	1.349	5.5	1.424	14.0	1.931	18.0	2.016	19.0	1.986	20.0	1.983	28.0	2.151
5.0	1.403	6.0	1.469	15.0	1.988	19.0	2.058	21.0	2.051	22.0	2.037	30.0	2.194
5.5	1.457	.5	1.513	16.0	2.045	20.0	2.100	23.0	2.116	24.0	2.090	32.0	2.236
6.0	1.510	.0	1.556	17.0	2.103	22.0	2.184	25.0	2.180	26.0	2.142	34.0	2.278
7.0	1.615	7.5	1.598	18.0	.160	24.0	2.267	30.0	2.340	28.0	2.193	36.0	2.319
8.0	1.719	8.0	1.641	19.0	2.217	26.0	2.351	35.0	2.499	30.0	2.244	38.0	2.360
9.0	1.823	9.0	1.725	20.0	.274	28.0	2.434	40.0	2.658	34.0	2.345	40.0	2.401
10.0	1.927	10.0	1.808	25.0	2.560	30.0	2.517	45.0	2.817	38.0	2.446	50.0	2.604
11.0	2.031	11.0	1.892	30.0	2.846					40.0	2.496	60.0	2.806
12.0	2.135	12.0	1.975							45.0	2.621	70.0	3.008
13.0	2.239	13.0	2.059							50.0	2.746		
14.0	2.343	14.0	2.142										
15.0	2.447	15.0	2.225										

$$\times\left[\frac{q(t_M-t_1)-q(t_M-t_2)}{\theta_2-\theta_1}\right]+\ldots+[P(\theta_{n-1})-P(\theta_n)]\left[\frac{q(t_M-t_{n-1})-q(t_M-t_n)}{\theta_n-\theta_{n-1}}\right]\Bigg\}$$

where the fluid-influx terms, $q(t)$, are determined for the various boundary conditions in the manner prescribed above for the "pressure case."

B. Linear Systems. The corresponding expressions for the rate case, pressure case, and rate of fluid influx for infinite linear systems are as follows:

1. *Rate Case*

$$P_o-P(O,\theta_M)=\frac{2}{a}\sqrt{\frac{\mu}{\pi\phi kc_t}}\Big\{Q(\theta o)\sqrt{\theta_M}+[Q(\theta_1)-Q(\theta_o)]\sqrt{\theta_M-\theta_1}+$$

$$[Q(\theta_2)-Q(\theta_1)]\sqrt{\theta_M-\theta_2}+\ldots+[Q(\theta_n)-Q(\theta_n-1)]\sqrt{\theta_M-\theta_n}\Big\}$$

2. *Pressure Case*

$$F_c(\theta_M)=2a\sqrt{\frac{\phi c_t k}{\pi\mu}}\Big\{[P_o-P(\theta_1)]\sqrt{\theta_M}+$$

$$[P(\theta_1)-P(\theta_2)]\sqrt{\theta_M-\theta_1}+\ldots+[P(\theta_{n-1})-P(\theta_n)]\sqrt{\theta_M-\theta_{n-1}}\Big\}$$

3. *Rate of Fluid Influx*

$$Q(\theta_M)=a\sqrt{\frac{\phi c_t k}{\pi\mu}}\Big\{\frac{[P_o-P(\theta_1)]}{\sqrt{\theta_M}}+\frac{[P(\theta_1)-P(\theta_2)]}{\sqrt{\theta_M-\theta_1}}$$

$$+\frac{[P(\theta_2)-P(\theta_3)]}{\sqrt{\theta_M-\theta_2}}+\ldots+\frac{[P(\theta_n-1)-P(\theta_n)]}{\sqrt{\theta_M-\theta_{n-1}}}\Big\}$$

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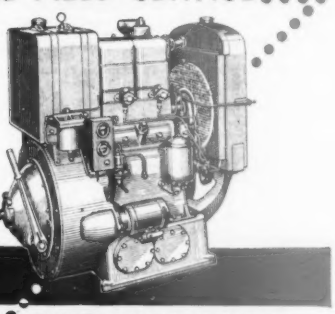

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TABLE 5. Finite radial system with fixed constant pressure at exterior boundary—Rate case.

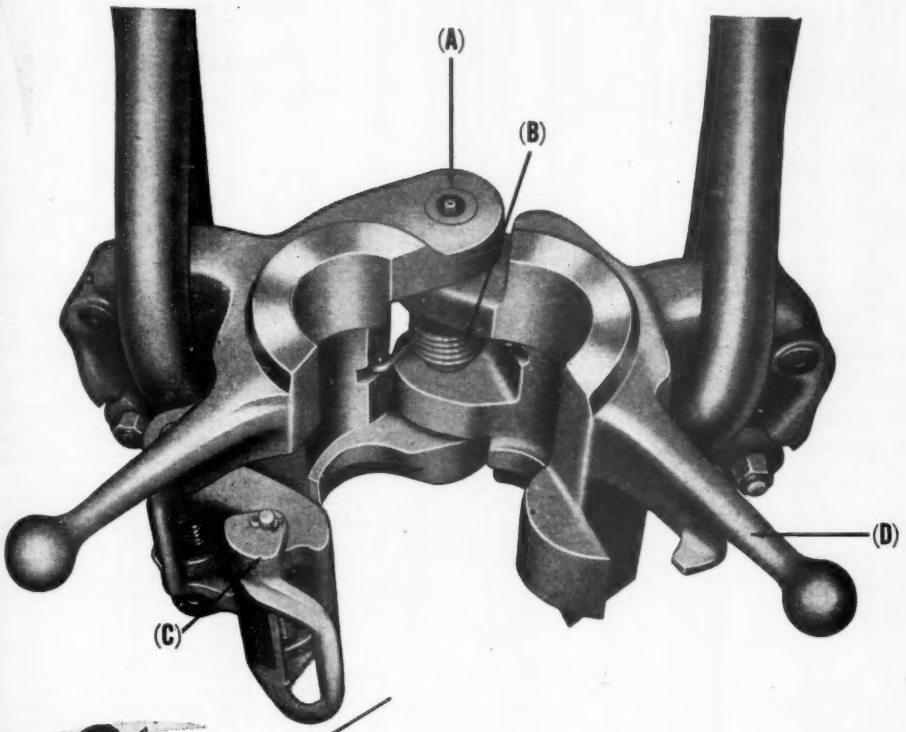
re/rw = 1.5		re/rw = 2.0		re/rw = 2.5		re/rw = 3.0		re/rw = 3.5		re/rw = 4.0		re/rw = 6.0		re/rw = 8.0	
Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change
t	p(t)	t	p(t)	t	p(t)	t	p(t)	t	p(t)	t	p(t)	t	p(t)	t	p(t)
$5.0(10)^{-2}$	0.230	$2.0(10)^{-1}$	0.424	$3.0(10)^{-1}$	0.502	$5.0(10)^{-1}$	0.617	$5.0(10)^{-1}$	0.620	1.0	0.802	4.0	1.275	7.0	1.499
5.5 "	0.240	2.2 "	0.441	3.5 "	0.535	5.5 "	0.640	6.0 "	0.665	1.2	0.857	4.5	1.320	7.5	1.527
6.0 "	0.249	2.4 "	0.457	4.0 "	0.564	6.0 "	0.662	7.0 "	0.705	1.4	0.905	5.0	1.361	8.0	1.554
7.0 "	0.266	2.6 "	0.472	4.5 "	0.591	7.0 "	0.702	8.0 "	0.741	1.6	0.947	5.5	1.398	8.5	1.580
8.0 "	0.282	2.8 "	0.485	5.0 "	0.616	8.0 "	0.738	9.0 "	0.774	1.8	0.986	6.0	1.432	9.0	1.604
9.0 "	0.292	3.0 "	0.498	5.5 "	0.638	9.0 "	0.770	1.0	0.804	2.0	1.020	6.5	1.462	9.5	1.627
$1.0(10)^{-1}$	0.307	3.5 "	0.527	6.0 "	0.659	1.0	0.799	1.2	0.858	2.2	1.052	7.0	1.490	10.0	1.648
1.2 "	0.328	4.0 "	0.552	7.0 "	0.696	1.2	0.850	1.4	0.904	2.4	1.080	7.5	1.516	12.0	1.724
1.4 "	0.344	4.5 "	0.573	8.0 "	0.728	1.4	0.892	1.6	0.945	2.6	1.106	8.0	1.539	14.0	1.786
1.6 "	0.356	5.0 "	0.591	9.0 "	0.755	1.6	0.927	1.8	0.981	2.8	1.130	8.5	1.561	16.0	1.837
1.8 "	0.367	5.5 "	0.606	1.0	0.778	1.8	0.955	2.0	1.013	3.0	1.152	9.0	1.580	18.0	1.879
2.0 "	0.375	6.0 "	0.619	1.2	0.815	2.0	0.980	2.2	1.041	3.4	1.190	10.0	1.615	20.0	1.914
2.2 "	0.381	6.5 "	0.630	1.4	0.842	2.2	1.000	2.4	1.065	3.8	1.222	12.0	1.667	22.0	1.943
2.4 "	0.386	7.0 "	0.639	1.6	0.861	2.4	1.016	2.6	1.087	4.5	1.266	14.0	1.704	24.0	1.967
2.6 "	0.390	7.5 "	0.647	1.8	0.876	2.6	1.030	2.8	1.106	5.0	1.290	16.0	1.730	26.0	1.986
2.8 "	0.393	8.0 "	0.654	2.0	0.887	2.8	1.042	3.0	1.123	5.5	1.309	18.0	1.749	28.0	2.002
3.0 "	0.396	8.5 "	0.660	2.2	0.895	3.0	1.051	3.5	1.158	6.0	1.325	20.0	1.762	30.0	2.016
3.5 "	0.400	9.0 "	0.665	2.4	0.900	3.5	1.069	4.0	1.183	7.0	1.347	22.0	1.771	35.0	2.040
4.0 "	0.402	9.5 "	0.669	2.6	0.905	4.0	1.080	5.0	1.215	8.0	1.361	24.0	1.777	40.0	2.055
4.5 "	0.404	1.0	0.673	2.8	0.908	4.5	1.087	6.0	1.232	9.0	1.370	26.0	1.781	45.0	2.064
5.0 "	0.405	1.2	0.682	3.0	0.910	5.0	1.091	7.0	1.242	10.0	1.376	28.0	1.784	50.0	2.070
6.0 "	0.405	1.4	0.688	3.5	0.913	5.5	1.094	8.0	1.247	12.0	1.382	30.0	1.787	60.0	2.076
7.0 "	0.405	1.6	0.690	4.0	0.915	6.0	1.096	9.0	1.250	14.0	1.385	35.0	1.789	70.0	2.078
8.0 "	0.405	1.8	0.692	4.5	0.916	6.5	1.097	10.0	1.251	16.0	1.386	40.0	1.791	80.0	2.079
		2.0	0.692	5.0	0.916	7.0	1.097	12.0	1.252	18.0	1.386	50.0	1.792		
		2.5	0.693	5.5	0.916	8.0	1.098	14.0	1.253						
		3.0	0.693	6.0	0.916	10.0	1.099	16.0	1.253						

re/rw = 10.0		re/rw = 15.0		re/rw = 20.0		re/rw = 25.0		re/rw = 30.0		re/rw = 40.0		re/rw = 50.0		re/rw = 60.0	
Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change
t	p(t)	t	p(t)	t	p(t)	t	p(t)	t	p(t)	t	p(t)	t	p(t)	t	p(t)
10.0	1.651	20.0	1.960	30.0	2.148	50.0	2.389	70.0	2.551	$12.0(10)^{1}$	2.813	$20.0(10)^{1}$	3.064	$3.0(10)^{2}$	3.257
12.0	1.730	22.0	2.003	35.0	2.219	55.00	2.434	80.0	2.615	14.0 "	2.888	22.0 "	3.111	4.0 "	3.401
14.0	1.798	24.0	2.043	40.0	2.282	60.0	2.476	90.0	2.672	16.0 "	2.953	24.0 "	3.154	5.0 "	3.512
16.0	1.856	26.0	2.080	45.0	2.338	65.0	2.514	$10.0(10)^{1}$	2.723	18.0 "	3.011	26.0 "	3.193	6.0 "	3.602
18.0	1.907	28.0	2.114	50.0	2.388	70.0	2.550	12.0 "	2.812	20.0 "	3.063	28.0 "	3.229	7.0 "	3.676
20.0	1.952	30.0	2.146	60.0	2.475	75.0	2.583	14.0 "	2.886	22.0 "	3.109	30.0 "	3.263	8.0 "	3.739
25.0	2.043	35.0	2.218	70.0	2.547	80.0	2.614	16.0 "	2.950	24.0 "	3.152	35.0 "	3.339	9.0 "	3.792
30.0	2.111	40.0	2.279	80.0	2.609	85.0	2.643	16.5 "	2.965	26.0 "	3.191	40.0 "	3.405	10.0 "	3.832
35.0	2.160	45.0	2.332	90.0	2.658	90.0	2.671	17.0 "	2.979	28.0 "	3.226	45.0 "	3.461	12.0 "	3.908
40.0	2.197	50.0	2.379	$10.0(10)^{1}$	2.707	95.0	2.697	17.5 "	2.992	30.0 "	3.259	50.0 "	3.512	14.0 "	3.959
45.0	2.224	60.0	2.455	10.5 "	2.728	$10.0(10)^{1}$	2.721	18.0 "	3.006	35.0 "	3.331	55.0 "	3.556	16.0 "	3.996
50.0	2.245	70.0	2.513	11.0 "	2.747	12.0 "	2.807	20.0 "	3.054	40.0 "	3.391	60.0 "	3.595	18.0 "	4.023
55.0	2.260	80.0	2.558	11.5 "	2.764	14.0 "	2.878	25.0 "	3.150	45.0 "	3.440	65.0 "	3.630	20.0 "	4.043
60.0	2.271	90.0	2.592	12.0 "	2.781	16.0 "	2.936	30.0 "	3.219	50.0 "	3.482	70.0 "	3.661	25.0 "	4.071
65.0	2.279	$10.0(10)^{1}$	2.619	12.5 "	2.796	18.0 "	2.984	35.0 "	3.269	55.0 "	3.516	75.0 "	3.688	30.0 "	4.084
70.0	2.285	12.0 "	2.655	13.0 "	2.810	20.0 "	3.024	40.0 "	3.306	60.0 "	3.545	80.0 "	3.713	35.0 "	4.090
75.0	2.290	14.0 "	2.677	13.5 "	2.823	22.0 "	3.057	45.0 "	3.332	65.0 "	3.568	85.0 "	3.735	40.0 "	4.092
80.0	2.293	16.0 "	2.689	14.0 "	2.835	24.0 "	3.085	50.0 "	3.351	70.0 "	3.588	90.0 "	3.754	45.0 "	4.093
90.0	2.297	18.0 "	2.697	14.5 "	2.846	26.0 "	3.107	60.0 "	3.375	80.0 "	3.619	95.0 "	3.771	50.0 "	4.094
$10.0(10)^{1}$	2.300	20.0 "	2.701	15.0 "	2.857	28.0 "	3.126	70.0 "	3.387	90.0 "	3.640	$10.0(10)^{2}$	3.787	55.0 "	4.094
11.0 "	2.301	22.0 "	2.704	16.0 "	2.876	30.0 "	3.142	80.0 "	3.394	$10.0(10)^{2}$	3.655	12.0 "	3.833		
12.0 "	2.302	24.0 "	2.706	18.0 "	2.906	35.0 "	3.171	90.0 "	3.397	12.0 "	3.672	14.0 "	3.862		
13.0 "	2.302	26.0 "	2.707	20.0 "	2.929	40.0 "	3.189	$10.0(10)^{2}$	3.399	14.0 "	3.681	16.0 "	3.881		
14.0 "	2.302	28.0 "	2.707	24.0 "	2.958	45.0 "	3.200	12.0 "	3.401	16.0 "	3.685	18.0 "	3.892		
16.0 "	2.303	30.0 "	2.708	28.0 "	2.975	50.0 "	3.207	14.0 "	3.401	18.0 "	3.687	20.0 "	3.900		
				30.0 "	2.980	60.0 "	3.214			20.0 "	3.688	22.0 "	3.904		
				40.0 "	2.992	70.0 "	3.217			25.0 "	3.689	24.0 "	3.907		
				50.0 "	2.995	80.0 "	3.218					26.0 "	3.909		
						90.0 "	3.219					28.0 "	3.910		

re/rw = 70.0		re/rw = 80.0		re/rw = 90.0		re/rw = 100.0		re/rw = 200.0		re/rw = 300.0		re/rw = 400.0		re/rw = 500.0	
Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change	Dimensionless time	Pressure change
t	p(t)	t	p(t)	t	p(t)	t	p(t)	t	p(t)	t	p(t)	t	p(t)	t	p(t)
$5.0(10)^{3}$	3.512	$6.0(10)^{3}$	3.603	$8.0(10)^{3}$	3.747	$1.0(10)^{3}$	3.859	$1.5(10)^{3}$	4.061	$6.0(10)^{3}$	4.754	$1.5(10)^{4}$	5.212	$2.0(10)^{4}$	5.356
6.0 "	3.603	7.0 "	3.680	9.0 "	3.806	1.2 "	3.949	2.0 "	4.205	8.0 "	4.898	2.0 "	5.356	2.5 "	5.468
7.0 "	3.680	8.0 "	3.747	$1.0(10)^{3}$	3.858	1.4 "	4.026	2.5 "	4.317	10.0 "	5.010	3.0 "	5.556	3.0 "	5.559
8.0 "	3.746	9.0 "	3.805	1.2 "	3.949	1.6 "	4.092	3.0 "	4.408	12.0 "	5.101	4.0 "	5.689	3.5 "	5.636
9.0 "	3.803	10.0 "	3.857	1.3 "	3.988	1.8 "	4.150	3.5 "	4.485	14.0 "	5.177	5.0 "	5.781	4.0 "	5.702
10.0 "	3.854	12.0 "	3.946	1.4 "	4.025	2.0 "	4.200	4.0 "	4.552	16.0 "	5.242	6.0 "	5.845	4.5 "	5.759
12.0 "	3.937	14.0 "	4.019	1.5 "	4.058	2.5 "	4.303	5.0 "	4.663	18.0 "	5.299	7.0 "	5.889	5.0 "	5.810
14.0 "	4.003	15.0 "	4.051	1.8 "	4.144	3.0 "	4.379	6.0 "	4.754	20.0 "	5.348	8.0 "	5.920	6.0 "	5.894
16.0 "	4.054	16.0 "	4.080	2.0 "	4.192	3.5 "	4.434	7.0 "	4.829	24.0 "	5.429	9.0 "	5.942	7.0 "	5.960
18.0 "	4.095	18.0 "	4.130	2.5 "	4.285	4.0 "	4.478	8.0 "	4.894	28.0 "	5.491	10.0 "	5.957	8.0 "	6.013
20.0 "	4.127	20.0 "	4.171	3.0 "	4.349	4.5 "	4.510	9.0 "	4.949	30.0 "	5.517	11.0 "	5.967	9.0 "	6.055
25.0 "	4.181	25.0 "	4.248	3.5 "	4.394	5.0 "	4.534	10.0 "	4.996	40.0 "	5.606	12.0 "	5.975	10.0 "	6.088
30.0 "	4.211	30.0 "	4.297	4.0 "	4.426	5.5 "	4.552	12.0 "	5.072	50.0 "	5.652	12.5 "	5.977	12.0 "	6.135
35.0 "	4.228	35.0 "	4.328	4.5 "	4.448	6.0 "	4.565	14.0 "	5.129	60.0 "	5.676	13.0 "	5.980	14.0 "	6.164
40.0 "	4.237	40.0 "	4.347	5.0 "	4.464	6.5 "	4.579	16.0 "	5.171	70.0 "	5.690	14.0 "	5.983	16.0 "	6.183
45.0 "	4.242	45.0 "	4.360	6.0 "	4.482	7.0 "	4.583	18.0 "	5.203	80.0 "	5.696	16.0 "	5.988	18.0 "	6.195
50.0 "	4.245	50.0 "	4.368	7.0 "	4.491	7.5 "	4.588	20.0 "	5.227	90.0 "	5.700	18.0 "	5.990	20.0 "	6.202
55.0 "	4.247	60.0 "	4.376	8.0 "	4.496	8.0 "	4.593	25.0 "	5.264	$10.0(10)^{4}$	5.702	20.0 "	5.991	25.0 "	6.211
60.0 "	4.247	70.0 "	4.380	9.0 "	4.498	9.0 "	4.598	30.0 "	5.282	12.0 "	5.703	24.0 "	5.991	30.0 "	6.213
65.0 "	4.248	80.0 "	4.381	10.0 "	4.499	10.0 "	4.601	35.0 "	5.290	14.0 "	5.704	26.0 "	5.991	35.0 "	6.214
70.0 "	4.248	90.0 "	4.382	11.0 "	4.499	12.5 "	4.604	40.0 "	5.294	15.0 "	5.704			40.0 "	6.214
75.0 "	4.248	$10.0(10)^{3}$	4.382	12.0 "	4.500	15.0 "	4.605								
80.0 "	4.248	11.0 "	4.382	14.0 "	4.500										

Continued.

WORLD'S BEST ELEVATOR

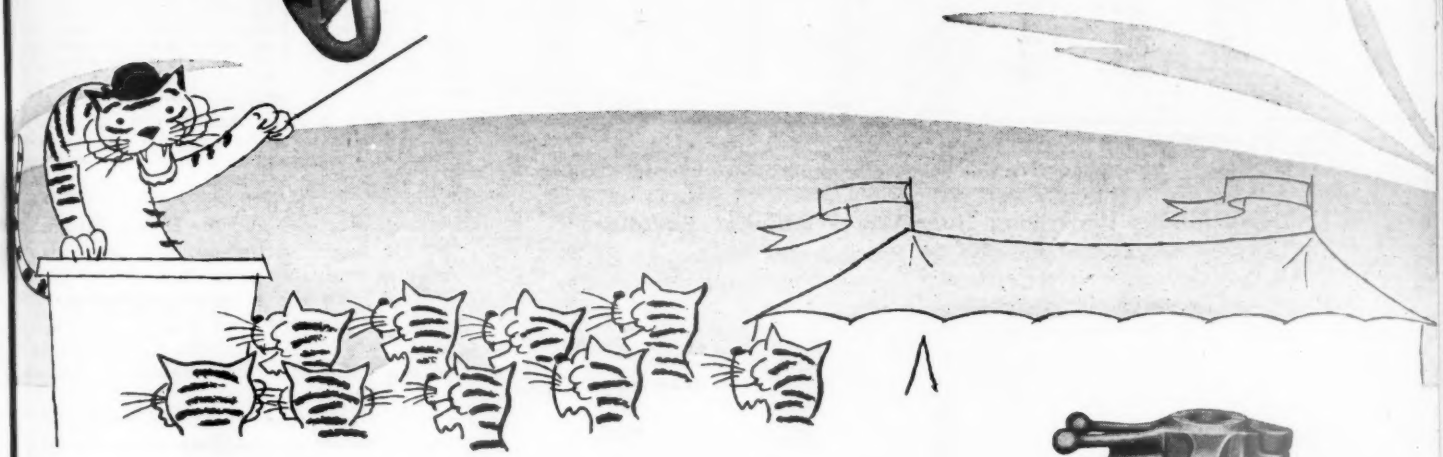


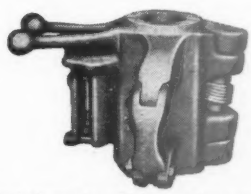
(A) This fitting (safely recessed in the hinge pin) permits proper lubrication to ensure easy opening and closing of elevator.

(B) This spring opens the elevator and forces it off and away from the pipe.

(C) The safety lock closes automatically with the latch; and one easy motion opens both lock and latch.

(D) Guards on handle protect hands from injury against the links.



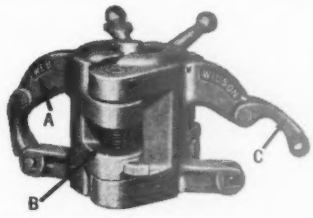


The slanted hinge pin, which provides automatic closing, is clearly seen above.

The *exclusive* features shown above are sufficient to make the Web Wilson "Balanced" Center Latch Elevator the WORLD'S BEST—and the choice of fast-moving, safety-minded crews—but there are **OTHER IMPORTANT FEATURES!** Remember that these "Balanced" elevators are made from Manganese-Molybdenum steel, properly heat treated—all pipe contacting surfaces are flame hardened to wear a long, long time—and see other advantages at right.

FOR ALL TYPES AND SIZES OF DRILL PIPE. Web Wilson "Balanced" Center Latch Elevators are available for Regular and External Upset "Collar Type" drill pipe, and also for "Bottleneck" (18-degree taper) drill pipe. Made in 12 sizes to handle drill pipe and tubing from 1¼" to 7".

YOUR supply store has Web Wilson "Balanced" Center Latch Elevators in stock—or can get one for you—pronto!



A–Rugged Link Arms fit links perfectly.
B–This spring opens the elevator and forces it off and away from the pipe.
C–Link Arms are easily operated, but are securely locked in place.

WEB WILSON Oil Tools INC.

FIELD PROVEN

LOS ANGELES, CALIFORNIA • HOUSTON, TEXAS • NEW YORK, N.Y.

TABLE 5. Finite radial system with fixed constant pressure at Exterior Boundary — Rate case. — (Continued)

re/rw=600.0		re/rw=700.0		re/rw=800.0		re/rw=900.0		re/rw=1000.0		re/rw=1200.0		re/rw=1400.0		re/rw=1600.0	
Dimensionless time t	Pressure change p(t)	Dimensionless time t	Pressure change p(t)	Dimensionless time t	Pressure change p(t)	Dimensionless time t	Pressure change p(t)	Dimensionless time t	Pressure change p(t)	Dimensionless time t	Pressure change p(t)	Dimensionless time t	Pressure change p(t)	Dimensionless time t	Pressure change p(t)
4.0(10)⁴	5.703	5.0(10)⁴	5.814	7.0(10)⁴	5.983	8.0(10)⁴	6.049	1.0(10)⁵	6.161	2.0(10)⁵	6.507	2.0(10)⁵	6.507	2.5(10)⁵	6.619
4.5 "	5.762	6.0 "	5.905	8.0 "	6.049	9.0 "	6.108	1.2 "	6.252	3.0 "	6.704	2.5 "	6.619	3.0 "	6.710
5.0 "	5.814	7.0 "	5.982	9.0 "	6.108	10.0 "	6.161	1.4 "	6.329	4.0 "	6.833	3.0 "	6.709	3.5 "	6.787
6.0 "	5.904	8.0 "	6.048	10.0 "	6.160	12.0 "	6.251	1.6 "	6.395	5.0 "	6.918	3.5 "	6.785	4.0 "	6.853
7.0 "	5.979	9.0 "	6.105	12.0 "	6.249	14.0 "	6.327	1.8 "	6.452	6.0 "	6.975	4.0 "	6.849	5.0 "	6.962
8.0 "	6.041	10.0 "	6.156	14.0 "	6.322	16.0 "	6.392	2.0 "	6.503	7.0 "	7.013	5.0 "	6.950	6.0 "	7.046
9.0 "	6.094	12.0 "	6.239	16.0 "	6.382	18.0 "	6.447	2.5 "	6.605	8.0 "	7.038	6.0 "	7.026	7.0 "	7.114
10.0 "	6.139	14.0 "	6.305	18.0 "	6.432	20.0 "	6.494	3.0 "	6.681	9.0 "	7.056	7.0 "	7.082	8.0 "	7.167
12.0 "	6.210	16.0 "	6.357	20.0 "	6.474	25.0 "	6.587	3.5 "	6.738	10.0 "	7.067	8.0 "	7.123	9.0 "	7.210
14.0 "	6.262	18.0 "	6.398	25.0 "	6.551	30.0 "	6.652	4.0 "	6.781	12.0 "	7.080	9.0 "	7.154	10.0 "	7.244
16.0 "	6.299	20.0 "	6.430	30.0 "	6.599	40.0 "	6.729	4.5 "	6.813	14.0 "	7.085	10.0 "	7.177	15.0 "	7.334
18.0 "	6.326	25.0 "	6.484	35.0 "	6.630	45.0 "	6.751	5.0 "	6.837	16.0 "	7.088	15.0 "	7.229	20.0 "	7.364
20.0 "	6.345	30.0 "	6.514	40.0 "	6.650	50.0 "	6.766	5.5 "	6.854	18.0 "	7.089	20.0 "	7.241	25.0 "	7.373
25.0 "	6.374	35.0 "	6.530	45.0 "	6.663	55.0 "	6.777	6.0 "	6.868	19.0 "	7.089	25.0 "	7.243	30.0 "	7.376
30.0 "	6.387	40.0 "	6.540	50.0 "	6.671	60.0 "	6.785	7.0 "	6.885	20.0 "	7.090	30.0 "	7.244	35.0 "	7.377
35.0 "	6.392	45.0 "	6.545	55.0 "	6.676	70.0 "	6.794	8.0 "	6.895	21.0 "	7.090	31.0 "	7.244	40.0 "	7.378
40.0 "	6.395	50.0 "	6.548	60.0 "	6.679	80.0 "	6.798	9.0 "	6.901	22.0 "	7.090	32.0 "	7.244	42.0 "	7.378
50.0 "	6.397	60.0 "	6.550	70.0 "	6.682	90.0 "	6.800	10.0 "	6.904	23.0 "	7.090	33.0 "	7.244	44.0 "	7.378
60.0 "	6.397	70.0 "	6.551	80.0 "	6.684	10.0(10)⁵	6.801	12.0 "	6.907	24.0 "	7.090				
		80.0 "	6.551	100.0 "	6.684			14.0 "	6.907						
								16.0 "	6.908						

re/rw=1800.0		re/rw=2000.0		re/rw=2200.0		re/rw=2400.0		re/rw=2600.0		re/rw=2800.0		re/rw=3000.0	
Dimensionless time t	Pressure change p(t)	Dimensionless time t	Pressure change p(t)	Dimensionless time t	Pressure change p(t)	Dimensionless time t	Pressure change p(t)	Dimensionless time t	Pressure change p(t)	Dimensionless time t	Pressure change p(t)	Dimensionless time t	Pressure change p(t)
3.0(10)⁵	6.710	4.0(10)⁵	6.854	5.0(10)⁵	6.966	6.0(10)⁵	7.057	7.0(10)⁵	7.134	8.0(10)⁵	7.201	1.0(10)⁶	7.312
4.0 "	6.854	5.0 "	6.966	5.5 "	7.013	7.0 "	7.134	8.0 "	7.201	9.0 "	7.260	1.2 "	7.403
5.0 "	6.965	6.0 "	7.056	6.0 "	7.057	8.0 "	7.200	9.0 "	7.259	10.0 "	7.312	1.4 "	7.480
6.0 "	7.054	7.0 "	7.132	6.5 "	7.097	9.0 "	7.259	10.0 "	7.312	12.0 "	7.403	1.6 "	7.545
7.0 "	7.120	8.0 "	7.196	7.0 "	7.133	10.0 "	7.310	12.0 "	7.401	16.0 "	7.542	1.8 "	7.602
8.0 "	7.188	9.0 "	7.251	7.5 "	7.167	12.0 "	7.398	14.0 "	7.475	20.0 "	7.644	2.0 "	7.651
9.0 "	7.238	10.0 "	7.298	8.0 "	7.199	16.0 "	7.526	16.0 "	7.536	24.0 "	7.719	2.4 "	7.732
10.0 "	7.280	12.0 "	7.374	8.5 "	7.229	20.0 "	7.611	18.0 "	7.588	28.0 "	7.775	2.8 "	7.794
15.0 "	7.407	14.0 "	7.431	9.0 "	7.256	24.0 "	7.668	20.0 "	7.631	30.0 "	7.797	3.0 "	7.820
20.0 "	7.459	16.0 "	7.474	10.0 "	7.307	28.0 "	7.706	24.0 "	7.699	35.0 "	7.840	3.5 "	7.871
30.0 "	7.489	18.0 "	7.506	12.0 "	7.390	30.0 "	7.720	28.0 "	7.746	40.0 "	7.870	4.0 "	7.908
40.0 "	7.495	20.0 "	7.530	16.0 "	7.507	35.0 "	7.745	30.0 "	7.765	50.0 "	7.905	4.5 "	7.935
50.0 "	7.495	25.0 "	7.566	20.0 "	7.579	40.0 "	7.760	35.0 "	7.799	60.0 "	7.922	5.0 "	7.955
51.0 "	7.495	30.0 "	7.584	25.0 "	7.631	50.0 "	7.775	40.0 "	7.821	70.0 "	7.930	6.0 "	7.979
52.0 "	7.495	35.0 "	7.593	30.0 "	7.661	60.0 "	7.780	50.0 "	7.845	80.0 "	7.934	7.0 "	7.992
53.0 "	7.495	40.0 "	7.597	35.0 "	7.677	70.0 "	7.782	60.0 "	7.856	90.0 "	7.936	8.0 "	7.999
54.0 "	7.495	50.0 "	7.600	40.0 "	7.686	80.0 "	7.783	70.0 "	7.860	10.0(10)⁶	7.937	9.0 "	8.002
56.0 "	7.495	60.0 "	7.601	50.0 "	7.693	90.0 "	7.783	80.0 "	7.862	12.0 "	7.937	10.0 "	8.004
		64.0 "	7.601	60.0 "	7.695	95.0 "	7.783	90.0 "	7.863	13.0 "	7.937	12.0 "	8.006
				70.0 "	7.696			10.0(10)⁶	7.863			15.0 "	8.006
				80.0 "	7.696								

Note: The numberical values in Tables 3, 4, and 5 and part of those in Table 2 were taken directly from the Hurst and van Everdingen report.[1] The values in Table 1 and those in Table 2 including the range $t = 1$ to $t = 125{,}000$ were supplied to the author by A. F. van Everdingen through the courtesy of the Shell Oil Company, and appear in publication for the first time.

Assumptions Underlying Hurst-Van Everdingen Equations

1. The effects of gravity on the fluid flow are neglected totally.
2. All flow through reservoir systems is assumed macroscopically laminar and thus governed by Darcy's law.
3. The sum expressed by Equation (24) is really the approximation

$$P_o - P(1, \theta_M) = \frac{\mu}{2\pi kh}\left\{Q(\theta_o)\, p(t_M) + \int_o^{\theta_M} \frac{d}{d\theta}\,[Q(\theta)]\, p(t_M - t)\, d\theta\right\}$$

$$\approx \frac{\mu}{2\pi kh}\left\{Q(\theta_o)\, p(t_M) + \sum_{i=1}^{n} [Q(\theta_i) - Q(\theta_{i-1})]\, p(t_M - t_i)\right\}$$

hence, increments of θ should be chosen as small as practicable.

4. Likewise, the sum expressed by Equation (31) is the approximation

$$F_c(\theta_M) = 2\pi\phi c_f r_w^2 h \int_o^{\theta_M} \frac{\partial \Delta P}{\partial \theta}\, q(t_M - t)\, d\theta$$

$$\approx 2\pi\phi c_f r_w^2 h \sum_{i=o}^{n} [P(\theta_i) - P(\theta_{i+1})]\, q(t_M - t_i)$$

hence, the increments of θ should here be also chosen as small as practicable.

5. Assumptions "3" and "4" apply to the corresponding expressions for linear systems.

6. For radial systems the relations $p(t) = 2\sqrt{t/\pi}$ and $pq(t) = 2\sqrt{t/\pi}$, for $t < 0.01$, are only close approximations of the rigorous equations.

7. The analytical results are based on ideal radial and linear symmetry.

8. Values for the pressure-change and fluid-influx terms are available only for specified boundary conditions.

9. The relation expressed by Equation (49) for obtaining the "annulus volume adjustment term," C, is an approximation based primarily on the assumption that the casing-head pressure is equivalent to a head of oil identical in height to the gas column in the annulus, throughout the bottom hole pressure decline. A value of C so obtained should suffice for most engineering purposes; however, if a more exact value is desired, then the actual casing-head pressure history of a well and the PVT relations of the fluids in the annulus must be used to evaluate the volume of fluid unloaded from the annulus per unit bottom-hole pressure drop, and, in general, the values of C determined with the aid of this ratio will vary with the bottom-hole pressure.

10. Only equivalent single-phase fluids that satisfy the thermodynamic relation

$$\rho = \rho_s [1 + c_f (P - P_s)]$$

can exist between the bounding surfaces of a system.

Acknowledgment

The author wishes to thank the management of the Magnolia Petroleum Company for permission to present this paper for publication. The author acknowledges the help of Charles R. Rahn, who prepared the graphs; of William L. Wahl, who checked the numerical accuracy of the calculations; and of Julius Aronofsky, Sam Faris, Paul Reichertż, and Terry Pollard of Magnolia's Field Research Laboratories, who reviewed the original manuscript. Grateful acknowledgment is also made to A. F. van Everdnigen of the Shell Oil Company, who provided the author with tabular information, and to Dr. Morris Muskat of the Gulf Oil Corporation, who reviewed the edited manuscript and made some valuable criticisms. * *

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- The Kelly itself is also accurately surveyed for straightness and must be straight within *one-eighth* inch when measured at any point over its entire length.
- The alignment of the projected axis of each threaded end, when checked with the precise Baash-Ross Alignoscope, *must* be within *one-eighth* inch of the longitudinal axis of the Kelly for each 10 ft. of Kelly length, or fraction thereof.
- In addition, threads *must* pass, not only all API specifications, but also unusually rigid Baash-Ross specifications on thread form, taper, lead, finish, etc.

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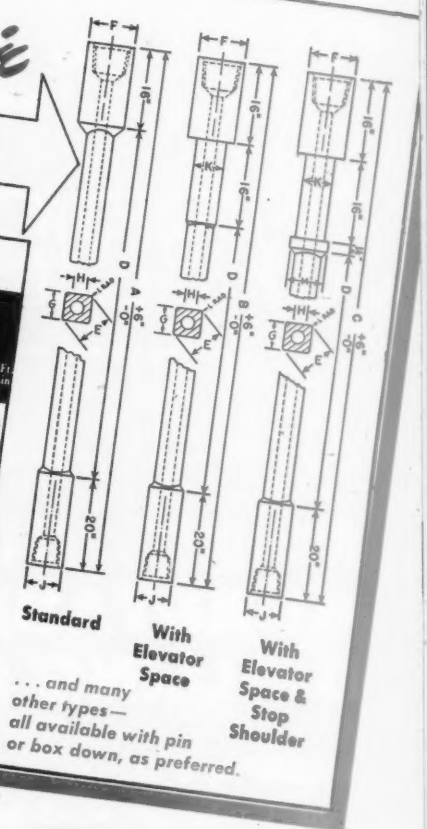
Nominal Size In.	LENGTHS: Overall A Ft.	Overall B Ft.	Overall C Ft.	Working Length D Ft.	Top Upset Joint Size A.P.I. Left Hand In.	Top Upset O.D. F In.	Bottom Upset Joint Size A.P.I. Right Hand In.	Bottom Upset O.D. J In.	Bore I.D. H In.	Across Corner E In.	Across Flat G In.	Elevator Space O.D. K In.	Corner Radius L In.	Stop Shoulder O.D. M In.	† Cu. Ft. per Lin. Ft.
5¼	35 38 40	36–4 39–4 41–4	36–6 39–6 41–6	32 35 37	4½ Reg. 6⅝ Reg.	5½"* 7⅝	2¾ Reg 2⅞ I.F.	3¼ 3⅝	1¹⁵⁄₁₆ 1¼	5⁹⁄₃₂	7⅛	2¹¹⁄₁₆	⁹⁄₁₆	3⅝	*.165 .327
5½	35 38 40	36–4 39–4 41–4	36–6 39–6 41–6	32 35 37	4½ Reg. 6⅝ Reg.	5½"* 7⅝	2¾ Reg 2⅞ I.F.	3¾ 4⅛	1¾ 1⅞	5¹³⁄₁₆	8	2¹³⁄₁₆	⅝	4⅛	*.165 .327
4½	35 38 40 44	36–4 39–4 41–4 55–4	36–6 39–6 41–6 55–6	32 35 37 41	4½ Reg. 6⅝ Reg.	5½"* 7⅝	3½ Reg. 3½ F.H. 3½ I.F.	4¼ 4⅝ 4⅞	1½ 2⅛ 2¼	4¹⁷⁄₃₂	5½	3¹⁹⁄₃₂	½	4¾	*.165 .327
5¼	38 40 44	39–4 41–4 55–4	39–6 41–6 55–6	35 37 41	6⅝ Reg.	7⅝	5½ Reg. 5½ F.H. 5½ I.F.	6¾ 7 7⅜	2¾ 2⅞ 3⅛	6²⁹⁄₃₂	8¼	5⅝	⅝	7	.327
6	38 40 44	39–4 41–4 55–4	39–6 41–6 55–6	35 37 41	6⅝ Reg.	7⅝	6½ Reg. 6⅝ F.H.	7¾ 8	3½ 3⅝	7⅛	9	6¾	⅝	8	.327

Sizes shown in RED are A.P.I. standard.
*Alternate 3¼ inches O.D. †180 cu. ft. per lineal ft
† Volume based on largest diameter of kelly



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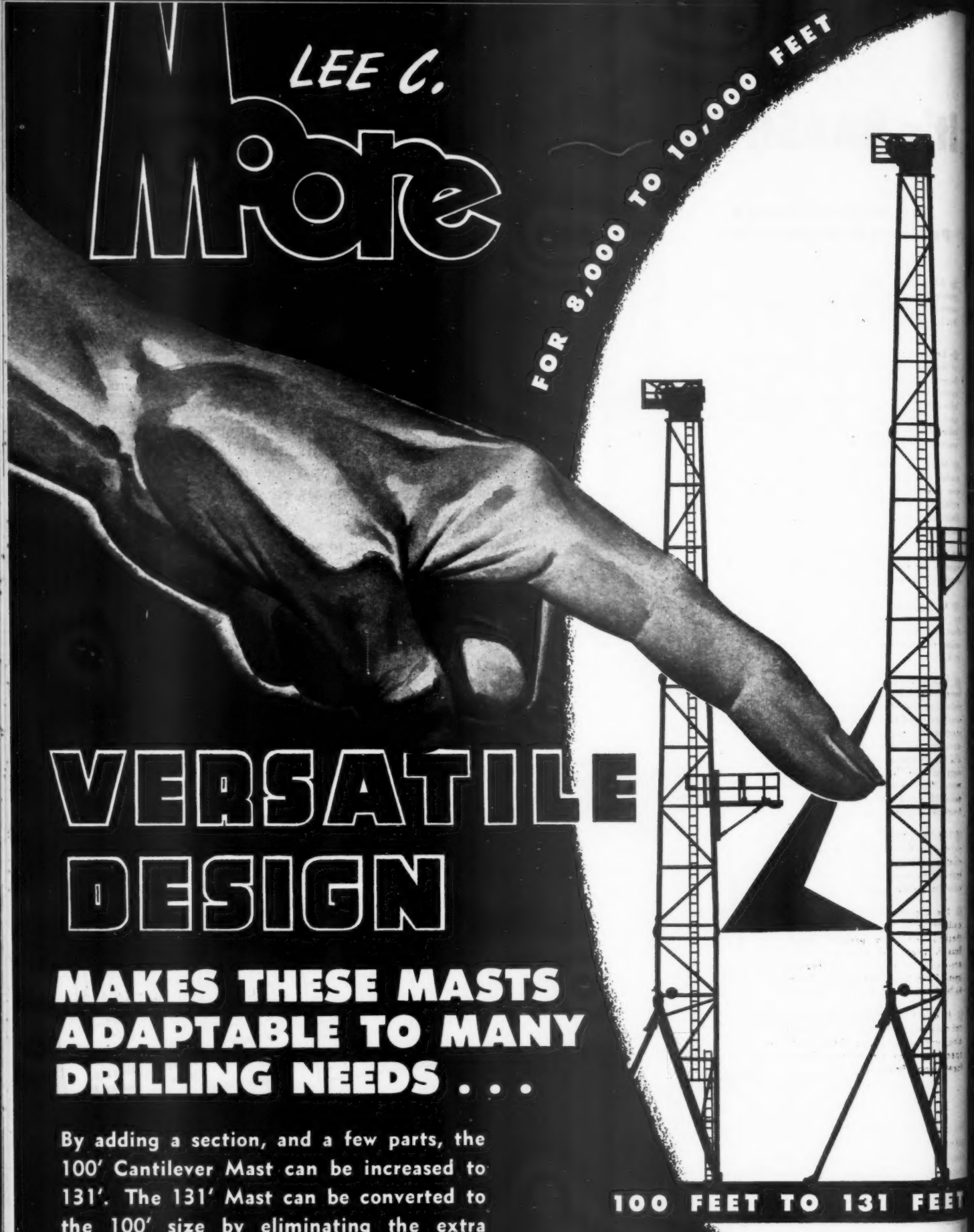

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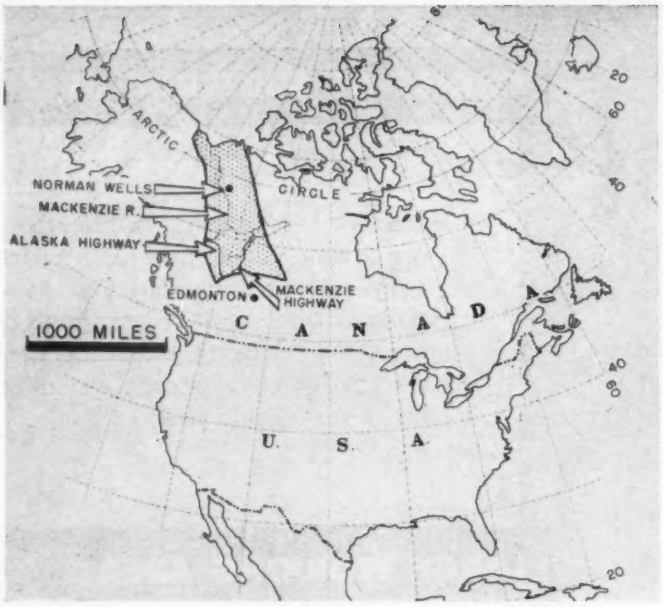


FIG. 1. "Muskeg Crawler" may be used soon in shaded area of Alberta and Northwest Territories.

Amphibious-type vehicle is designed to traverse muskeg and snow.

MUSKEG CRAWLER

Dependable transportation will allow summer exploration in Canada's muskeg swamps

G. REMPEL

THOUSANDS of square miles of muskeg country that have been inaccessible to oil searchers in northern Alberta, northeast B. C. and the Northwest Territories may soon be conquered by an amphibious-type vehicle called the "Muskeg Crawler." It is the result of four years of experimenting with transportation equipment in northern muskeg and snow.

Designed by Imperial Oil's geophysical engineers, the 14-ft boat-like vehicle is an all track unit with bearing weight of less than two pounds per square inch. Power is transmitted to the tracks separately, with individual and simultaneous control of tracks in both forward and reverse. In addition to being able to float, the "Muskeg Crawler" can transport a payload of at least 2000 lb and has a maximum effective speed of 16 miles per hour. For the most part, all parts are standard and should be obtainable at local garages and supply houses.

Although the pilot model has been subjected to many tests and has undergone improvements as a result of these tests, some field tests have yet to be made. "However," say its designers, "tests to date have been definitely encouraging." As a result United Trailers of Calgary has been authorized by Imperial Oil to produce the vehicle on a commercial basis and so make it available to other companies as well.

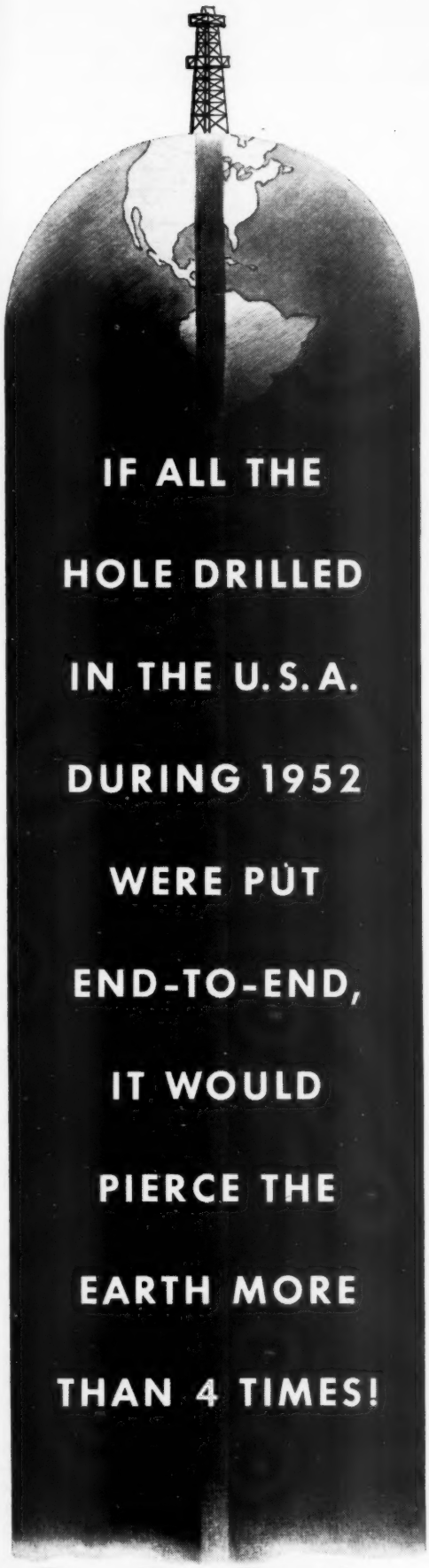
The "Muskeg Crawler" is the result of developments that followed the discovery of oil in the Leduc and Redwater districts in 1947-48. As the search for new fields widened attention was focused on the 400,000 sq. miles of favorable country in northern Alberta and the Northwest Territories. (Fig. 1) Here the oil prospectors soon learned that during seven-and-a-half months of the year this land is an inaccessible region of bush, soggy muskeg, and meandering streams. Operations with conventional wheel equipment was only possible when this terrain was frost hardened during the four-and-a-half winter months when temperatures reached fifty below zero. This short term operational period proved to be costly and unsatisfactory. What was needed was transportation that could operate 12 months of the year.

Initial efforts at year-round operation made use of horses as a means of transportation. All equipment was portable and an entire seismic crew, including equipment and members, was carried by 12 to 14 horses. While this was a step

EXCLUSIVE

The Author

Gerry Rempel is exploration equipment engineer for Imperial Oil at Edmonton, Canada. He joined the Canadian Army and was a P. T. instructor at Camp Borden, near Toronto in 1941. After receiving his discharge, he entered University of Saskatchewan in Saskatoon to study physics. In the spring of 1948 he joined Imperial at Edmonton on seismic work, first as an instrument operator and later as a party chief. It was in this work he ran into Muskeg. He was named to his present position in 1951, and much of his work is concerned with the development of equipment for use in Muskeg country including safety factors.



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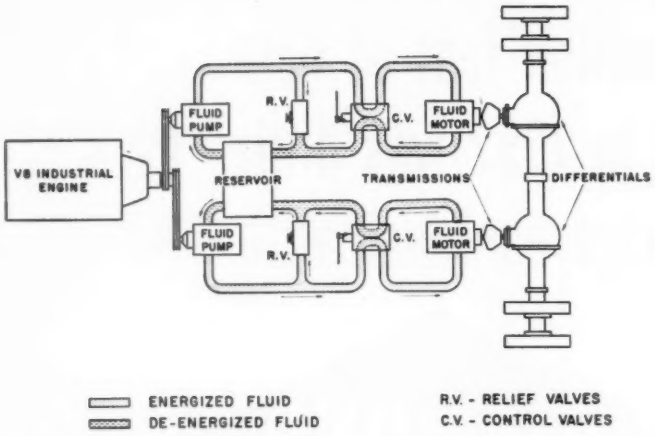

FIG. 2. Control valves in fluid circuits control power and direction of tracks.

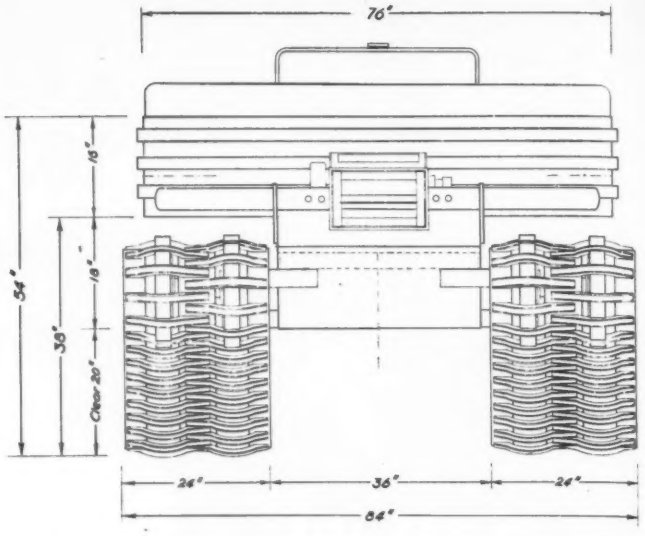

FIG. 4. Center to center distance between tracks is 60 in. and each track is 24 in. wide.

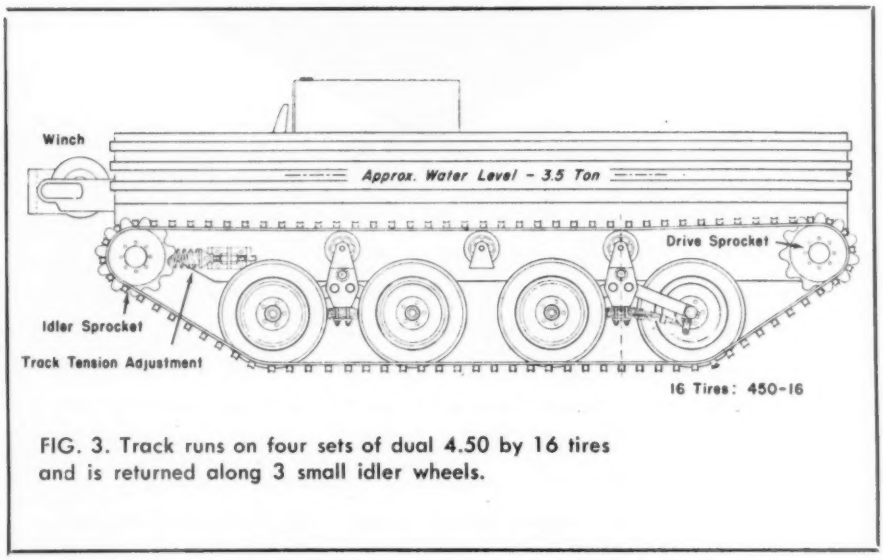

FIG. 3. Track runs on four sets of dual 4.50 by 16 tires and is returned along 3 small idler wheels.

in the right direction still vast areas remained inaccessible to the mounted prospectors. But it was the slowness of this method that prompted Imperial Oil to experiment with a variety of commercial and military type vehicles in use in the north.

Their experiments revealed that the commercial and military vehicles under study were suitable for the purposes for which they were designed, but they did not fully answer the needs of crews prospecting in the muskeg. What was needed was a vehicle that would "meet the fundamental requirements of low ground pressures, mechanical simplicity, power, speed and maneuverability, ruggedness, and safety of operation."

Guided by these requirements, Imperial took all the good features of equipment in use in northern Canada and combined them in an experimental vehicle using an all hydraulic drive with steering accomplished by differential power control. This hydraulic system was the most radical departure from the design of conventional or special equipment used in the north. In place of the usual mechanical drive, the unit diverted the engine power into two separate hydraulic pump and motor systems. This means of power transmission enabled each track to be driven independently of the other, with full range of power both forward and reverse in each track.

Details

Drive shaft of the "Muskeg Crawler" engine is coupled by high speed chains and sprockets to two hydraulic pumps. Each hydraulic motor powers one of the rear track drive sprockets through a modified Ford one-ton transmission and differential. This means of power transmission makes the vehicle performance almost identical in forward or reverse.

Control valves, (Fig. 2) one in each of the separate fluid circuits, independently control the power and direction of the respective tracks. In addition to the control valves, each separate fluid circuit is provided with an automatic relief valve which automatically regulates the maximum operating pressure of 2000 psi. This pressure gives a theoretical maximum fluid motor output of 97.5 ft lb of torque or 31.5 hp at 1700 rpm.

Power source of the "Muskeg Crawler" is a "337" V-8 Lincoln Industrial engine, which has more than enough power to drive the hydraulic components at maximum allowable pressures. Maximum torque developed at each final drive sprocket is in the neighborhood of 500 ft lb in high gear or over 2000 ft lb in low gear. Top speed of the unit is about 16 miles per hour.

The front idler sprockets are spring loaded and the track tension is regulated by increasing or decreasing this spring action. (Fig. 3) Each track runs on four sets of dual 4.50 X 16 tires and is returned along 3 small idler wheels. The two front and two rear dual wheel assemblies of each track are independently suspended from the chassis. This suspension consists of a trunion system which allows vertical movement of individual duals. For further trunion and spring action, the assembly is suspended from the body by a shaft mounted bracket. This allows each pair of wheel assemblies to rotate about the shaft. The track suspensions are laterally rigid. Each track, which is 24 in. in width, consists of three strips of steel cored rubber belting with adjacent strips being connected by metal cross-overs or growsers. Power is applied to the track through the growsers by means of the rear sprocket.

Center to center distance between tracks is 60 in. (Fig. 4) Since each track is 24 in. wide and has 96 in. of its length on the ground, the total ground contact area is 5000 sq in. The total gross weight of the vehicle is approximately 9500 lb, which results in a ground pressure in the order of 1.9 psi. When not floating, this pressure will allow the vehicle to cross terrain considerably softer than that required to support a man walking. * * *

Methods and Advantages of Determining Gravities of Crude in Oil-Bearing Rock Samples

Pre-production knowledge of grading is gained by use of water-alcohol suspension or refractometer

DR. JOHN O. NIGRA

ABSTRACT

Methods are described by which the specific gravity of minute quantities of crude, such as could be extracted from wire line cores, can be determined within reasonable limits of accuracy. One of these, the water-alcohol suspension method, is hydrometric and indirect. The other, the refractometer method involves establishing a local relationship between refractive index and specific gravity. A tentative conversion graph, utilizing the linear relationship between Refractive Index (N_D) and Sp. Gr. existing among the aliphatic hydrocarbons, is presented.

The relative advantages of determining oil gravities from cores are discussed and evaluated. Pre-production knowledge of petroleum grading, evidenced from gravities, is deemed essential to an expediential completion of the well and, also, to the form of crude segregation that could be made synchronous with refinery requirements.

The Author

John O. Nigra is associate professor of geology, Tulane University, New Orleans, Louisiana. He was graduated from the University of Texas College of Mines in 1937 and obtained his doctor's degree at the University of Mexico graduate school in 1951. His experience has been varied and he has worked both in Mexico and the United States. He was a research geologist for Arabian American Oil Company in New York City in 1951, and investigator cientifico, Instituto Geologico Nacional and Petroleos Mexicanos, Mexico City in 1950. He has been an instructor at the Orange Coast College, Pasadena City College, California Institute of Technology, and Texas A. & M.

In business he was with Barnsdall Oil, Bethlehem Steel, Sonoma Quick-Silver Company and Contact Mining, Texas Petroleum Company, and Lago Petroleum. He accepted his present position in 1952.

AMONG the physical characteristics of hydrocarbons, one of the most determinative and diagnostic is specific gravity. In the case of a crude oil, even though an admixture of petroleum hydrocarbons is represented, the determination of its average gravity corrected for temperature readily aids identification and grading of the product. This is especially true with production and refinery crudes; but, where crude in an oil-bearing rock sample is concerned, the determination of gravity becomes a problem.

It is easily apparent that in a core or outcrop sample harboring natural oil the contents would be so restricted in quantity that it would be physically impossible to arrive at oil gravity determination by usual means. This fact was of small consequence until the value became appreciated of arriving at fairly accurate gravity estimates before well completion and production. Previously, it was the custom to guess at probable gravities of oil in cores, usually with a great deal of inconsistency and a magnitude erroneously varying mostly with the quantity of crude in the sample (i.e., the more oil saturated the core, the greater the tendency to guess at higher gravities).

Hedberg (1937) and Refshauge (1951), experimenting independently with crudes in Venezuela, were able to arrive at a practical development of a method of determining oil gravities from cores by means of the refractive index of oil. Although the uniform relationship of specific gravity to refractive index of a hydrocarbon product of mixed density, such as a petroleum crude, is open to question, there exists no doubt that Hedberg and Refshauge developed techniques that are significantly practicable and allow useful interpretative results.

The writer has had the opportunity of employing a modification of these techniques in Venezuela and Mexico and in so doing has been able to evaluate the refractive index method as well as the water-alcohol method of determining oil gravities from cores. This latter indirect method has the same advantage as the first in that minute quantities of crude can be employed in determining oil gravity; however, it has some concomitant disadvantages which will be discussed in the text. In any case, the objectives of this report will be to show the decided geological and engineering advantages of a precompletion and preproduction determination of petroleum gravities, as well as the means by which this can be achieved.

EXCLUSIVE

Extraction of Oil From Sample

It has been the general experience of the writer that oil, unless occurring in richly abundant quantities, has to be extracted from rock samples by use of some organic solvent. Infrequently, it is possible to procure a drop or more of free oil from the interior of a core using a glass rod or a small brush. This is particularly true if the core is of the larger diameter conventional core-barrel type. Usually, in the case of cores taken with wire-line retrievable core-barrels, drilling mud contamination and emulsification are found present. This varies, naturally, with the degree of induration of the particular oil-sand or with the character of porosity of an oil-bearing limestone or similarly dense rock. In some instances, it is quite possible to smear off a film of free oil wherever shale partings occur in an oil-sandstone.

To the contrary notwithstanding, therefore, it is best to be prepared to extract oil from the average rock sample by means of a volatile solvent. The solvent in question should have a boiling point lower than that of most of the liquid hydrocarbons present in the oil. Octane, for example, has a boiling point of 258.20 F at 760 mm; consequently, this requirement does not pose too great a problem. Carbon tetrachloride with a BP of 168-8 F at 760 mm, has been found by the writer to be the best suited for oil extraction from cores in this case, although acetone and chloroform have also been employed among other organic solvents.

In the event the particular rock sample bearing the oil to be tested is extremely hard, dense, well-compacted, and cemented or, if the quantity of oil is hardly detectable, being present only as a stain or as hydrocarbon odor, it will be necessary to employ a Soxhlet type apparatus for extraction. This equipment consists of a sealed chamber in

which to place the sample, a distillation unit with a water jacket, and a bottom flask for the solvent and dissolved oil, having a by-pass connection for the siphoned return of the solvent distillate after it has washed over the sample. Usually, the core fragment is purged until the solvent in the sample chamber is seen to remain uncolored, and in some instances this could take several hours. In the instance of a friable oilsand or an oil saturated core, it is sufficient to break the rock sample down in a mortar, to add an excess of carbon tetrachloride, and to allow it to stand for a few minutes. Some laboratories even employ a centrifuging system in this connection.

Whether the Soxhlet apparatus or a simpler method is employed for the extraction, the resulting solution of oil and solvent is filtered into an evaporating dish. the filtrate is then placed on a hot plate or a water bath and allowed to evaporate slowly (preferably under a hood) until only a small quantity of the liquid remains. The final evaporation should proceed at ordinary room temperature until the oily residue remains in the form of a film over the porcelain of the dish or, if the quantity has been abundant, in the form of a few minute globules of oil. If only the film remains, a policeman (rubber-tipped glass stirring rod) can be used to collect it into a drop or more of oil. If the residue oil from this process is to go on the fixed prism of a refractometer in the form of a smear, it might be well to allow a trace of carbon tetrachloride to remain in the evaporating dish with the residue, because by the time the residue is placed on the instrument the remaining solvent will have volatilized.

It should be apparent that extreme care should be taken in evaporating the filtrate from the extraction process so as not to lose too many of the hydrocarbon light-ends. Also, the time interval between extraction and gravity determination of the oil should be reduced to as little as possible as one is dealing with mixed hydrocarbons in extremely small quantities that can become quickly inspissated. With a little practice and patience it will be found possible to effect oil extraction from rock samples with a fair degree of efficiency.

Water-Alcohol Suspension Method

This is an indirect method for determining oil gravities. The hydrometric technique involved consists of adjusting an alcohol-water mixture to a gravity commensurate with that of the oil.

After the extraction process has been completed, a drop of oil is taken from the evaporating dish and introduced into a water-alcohol filled graduated flask (or any similar laboratory receptacle) long enough to permit the insertion of a hydrometer (preferably also graduated to API scale). If there is any pre-conception of the probable specific or API gravity of the oil, it is desirable to adjust the water-alcohol mixture to a point slightly lower than which has been estimated. Then if after adding the drop of oil to the mixture it is observed to sink, additional water should be poured very slowly and carefully down the sides of the flask until the drop of oil regains differential buoyancy and begins to float. The ideal mixture ratio of water to alcohol would be at that point where the drop of oil is suspended between the surface and the bottom of the container. Should this point be passed by the addition of too much of the heavier liquid, it may be necessary to bring it back by adding alcohol.

Obviously, it is highly undesirable to fluctuate too many times in the addition of the two liquids in making up the correct gravity mixture, because of the possibility of breaking up the submerged oil and dispersing it into several meaningless droplets. If the mixture should be made heavier than the oil, the ensuing flotation of the drop will tend to aerate it and fill it with small bubbles of air which are hard to eliminate. The effects of surface tension, also the possible retention of traces of solvent[1] or other impurities from the extraction process, introduce further sources of error and aggravate the limitations of this method. It should be mentioned, however, that while its technique is more troublesome than for the refractive index method and its accuracy less acute, the water-alcohol suspension method has the advantages of not requiring an expensive instrument for its implementation and of yielding oil grav-

[1]Specific Gravity of Carbon Tetrachloride is 1.595 at 20 C, of Ethyl Alcohol 0.7893 at 20 C, and of Methyl Alcohol 0.7928 at 20 C.

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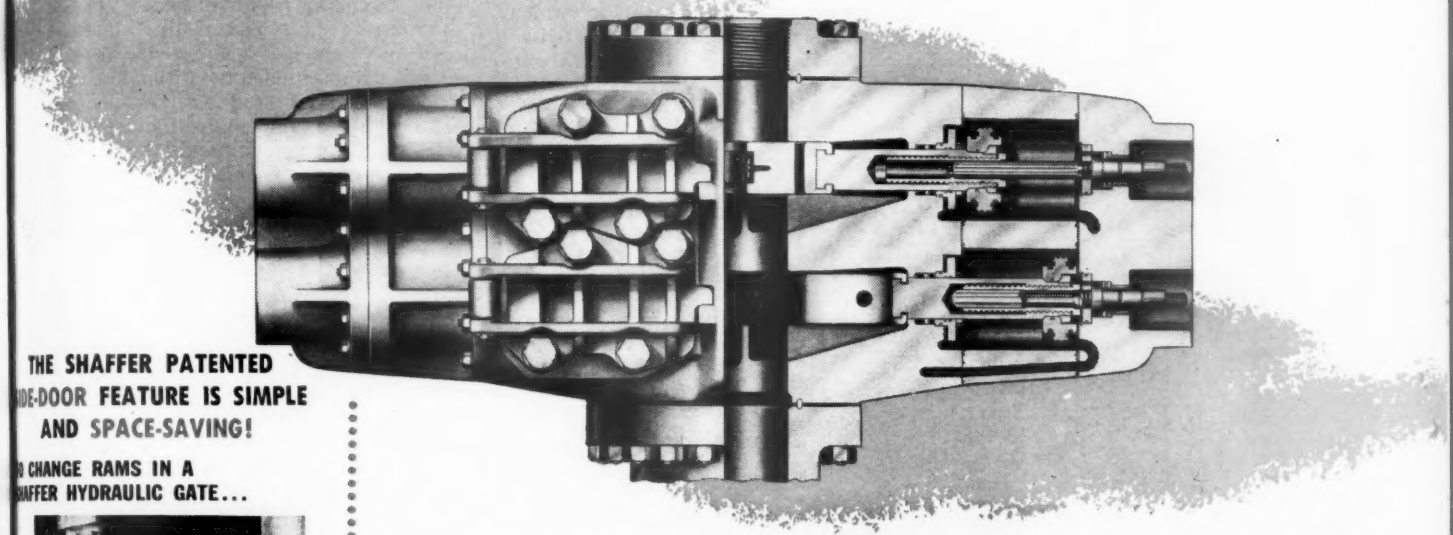

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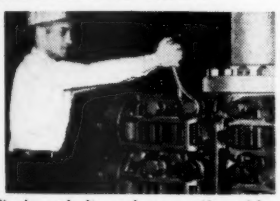
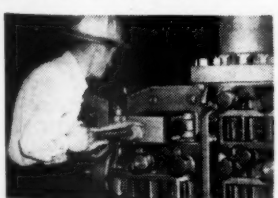


1. Simply unbolt and open the side door...

2. Slide out the ram assembly...



3. Replace rams, and slide the assembly back in place...

4. Close and bolt the door.

Closing the door automatically aligns the ram assemblies in the gate body!

It's the simplest, fastest—and most space-saving design available. And complete ram changes can be made with pipe in or out of the hole!

Compactness is something to *double*-check when you buy cellar control gates. *Why?* Because overall dimensional data that *seems* comparable may not be at all similar on closer inspection.

For example — the Shaffer Hydraulic Double Cellar Control Gate in sizes as large as 13⅜" (12" Series 900) has an overall length of less than 89". (Smaller sizes even less.) This length is fixed — *there's no need to add additional cellar space to allow for opening and extending the gate in order to change the rams!*

Shaffer rams are quickly and easily changed through *side-opening* doors that open along the *minimum* horizontal dimension of the gate — therefore do not add extra space to the critical longest dimension of the unit!

Another space-saving advantage made possible by the patented Shaffer *side-door* feature is that no added space need be allowed *above* Shaffer Gates in order to change rams. You can mount Shaffer Hydraulic Cellar Control Gates even in cellars with minimum height and not have to worry about "working clearance" above the unit to allow for ram changes . . . because the rams are changed from the *side* — not from the top!

REMEMBER — **the two most critical dimensions of a cellar control gate are length and height. Shaffer Hydraulic Cellar Control Gates do not require added space in either of these dimensions in order to change rams — a vital space-saving advantage that makes Shaffer compactness really mean something!**

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ity results well within the margins of practicality and useful evaluation.

Refractive Index Method

A useful physical criterion of a transparent or translucent substance is its refractive index, that is, the ratio of the velocity of light in air to the velocity of light in the substance. This ratio or refractive index is related to the extent to which a ray of light is deflected when going from one medium to another by the mathematical expression of $N_2 \sin R = N_1 \sin I$, where N_1 and N_2 are indices of refraction of media 1 and 2 respectively, I is the angle of incidence, and R the angle of refraction. Each angle is measured from interface normal to ray.

Generally speaking, the refractive indices of petroleum oils range from ± 1.40 to ± 1.60, which is well above the refractive index for water (1.333 at 20 C). This appears to be an anomaly to the belief that the index of refraction would be smaller for the less dense of the two media, (petroleum oil and water). Nevertheless, it must be recalled that petroleum is not chemically homogeneous but represents a mixture of a number of different compounds whose collective index of refraction bears no uniform relationship to their respective densities.

In implementing the refractive index method for determining oil gravities, it is necessary to have a refractometer for measuring the relative rate at which light travels in the oil as compared to its speed in air. Then, after obtaining an index reading on the instrument it becomes a problem of graphical conversion to specific gravity and subsequently to API gravity, if desired. The Abbe refractometer is the type generally employed in industrial laboratories. Its use in the calibration of oils for petrographic and optical mineralogic work is well known by geologists.

If the angle of incidence made by a ray of light is varied, it is found that beyond a certain definite angle refraction no longer occurs but total reflection begins. This is the so-called critical angle, and its measurement forms the underlying principle of most refractometers including the Abbe-type. These instruments are manufactured either with or without Amici compensating prisms. Refractometers without these prisms must be used with monochromatic light. Instruments with compensations may be used with white light. The function of the Amici compensating prisms is to collapse the spectrum that results from dispersion of white light passed through the sample and measuring prisms to a sharp edge such as is obtained with monochromatic light. The Amici prisms are designed so that the edge is at the position for sodium D light and 20 C. These prisms are rotatable and the position of their rotation when the edge is sharp permits an estimate of the dispersion.

The order of procedure in determining the refractive index of a petroleum oil (any transparent liquid, for that matter) with a refractometer having compensating prisms is as follows:

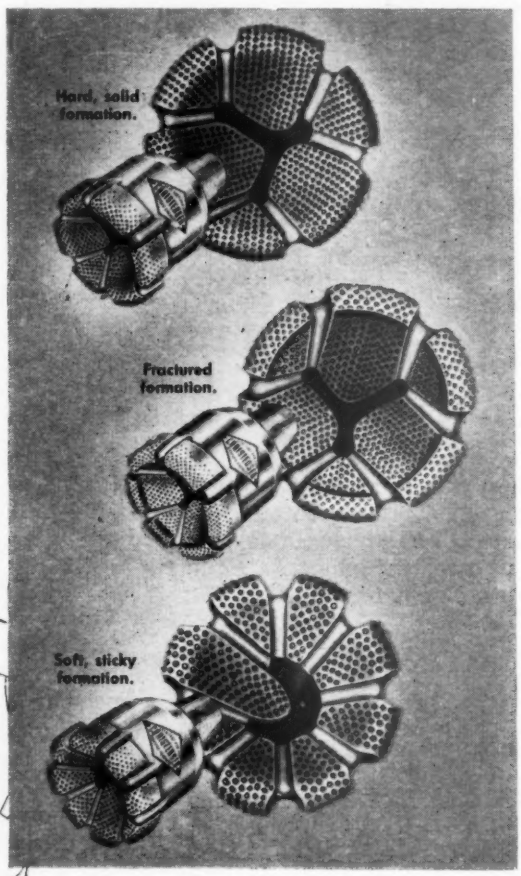
1. Be sure that the surface of the bottom illuminating prism and the surface of the top measuring prism, between which the oil is placed, are perfectly clean. This should be accomplished by washing the surfaces with alcohol and carefully wiping them with soft, clean cotton or with lens paper.

2. Place a drop or two of the oil to be tested on the ground surface of the illuminating prism. If the oil was extracted from the rock sample by means of a solvent such as carbon tetrachloride,[2] care should be exercised that the solvent has completely evaporated before bringing the two refractometer prisms together and clamping them into position. By maneuvering the telescope arm into a convenient observing position, it is easy at this point to determine whether or not the oil being tested actually makes contact with the entire prism surface. If not, the prisms should be unclamped, swung back out of position, and the oil spread evenly over the surfaces of both prisms.

3. Adjust the mirror below the prisms so that light is directed into them.

4. Release hand positioning control clamp and move the lever arm slowly by hand until a dividing line is observed through the telescope. To be sure that the dividing line is truly due to refraction and not a spurious effect associated with irregular brightness of the source,

[2] N_D of $CCl_4 = 1.4630$ at 15 C. The name officially approved for this compound by the International and Chemical Union is *Tetrachloromethane.*



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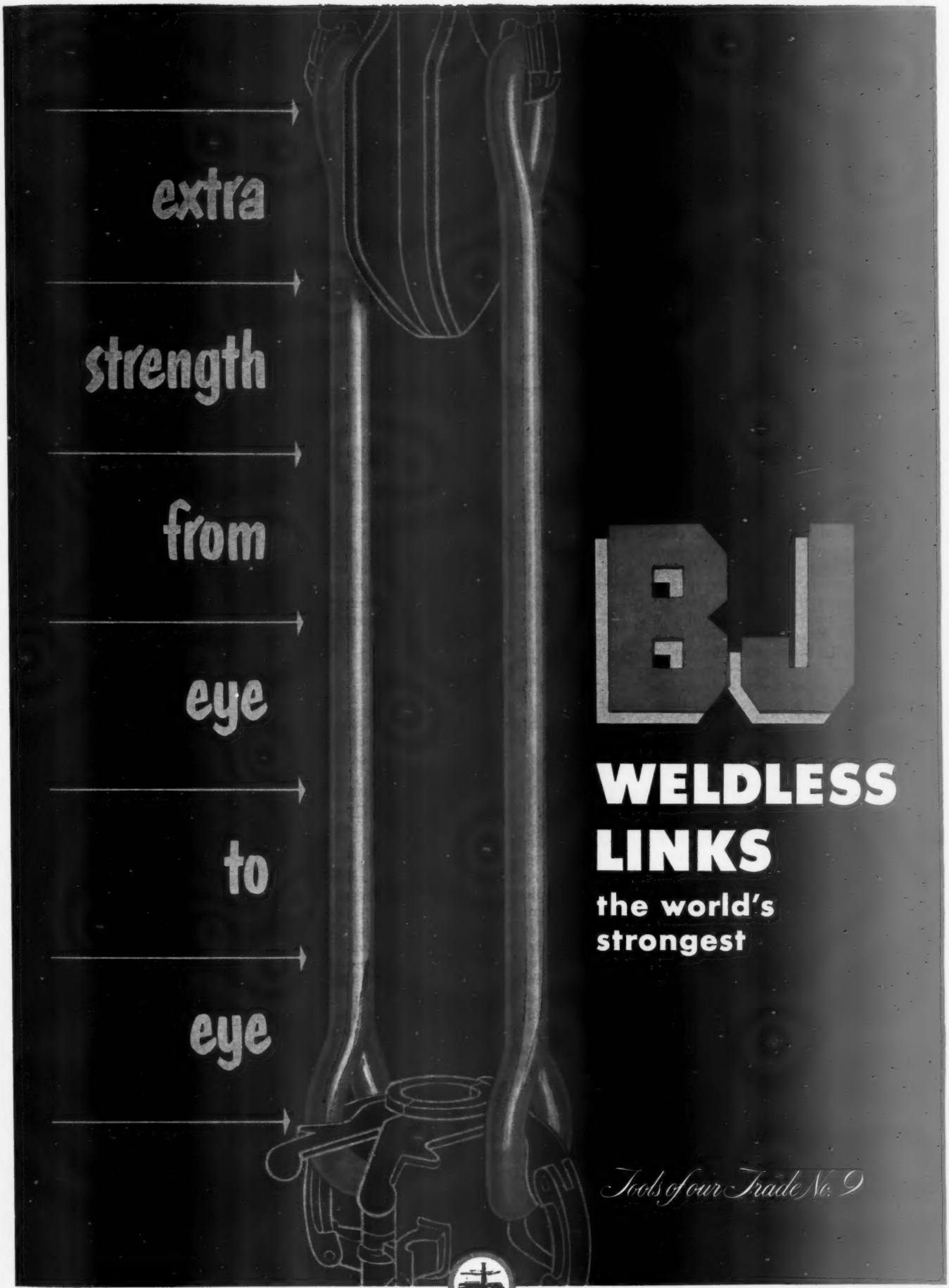

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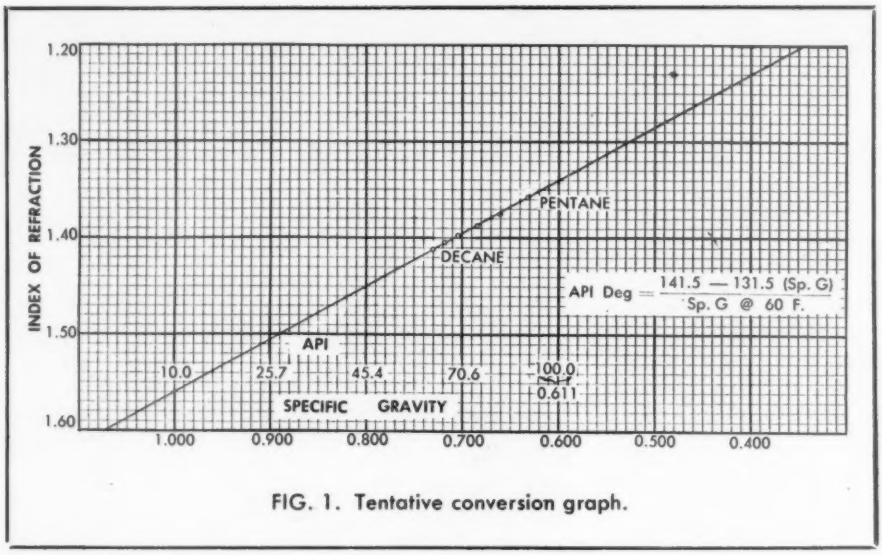


FIG. 1. Tentative conversion graph.

move the mirror slightly. If the dividing line moves, it is spurious. The mirror should be moved to clear the spurious dividing line from the field and the true dividing line sought again.

5. Focus the eyepiece tube until the dividing edge of the field and the cross hair of the eyepiece are both in sharp focus.

6. Adjust the rotating or "compensator" drum until the dividing line becomes sharp and as free from color as possible. With the dividing edge of the field sharply in focus near the center of the field and free from color, clamp the hand positioning control clamp. By means of the tangent screw fine adjustment, move the dividing edge until is is in exact coincidence with the center of the cross hair.

7. Read the refractive index directly by observing the scale of the alidade arm through the scale magnifier. The scale may be read directly to the third decimal place and the fourth may be estimated with an accuracy of ± 0.0002.

To read the index of refraction using a refractometer without compensating prisms, the same foregoing procedure may be followed. The instrument, however, must be used with monochromatic light of 589 mu wave-length like that produced by a sodium vapor lamp. The field will appear as orange and black, and no color compensation will be necessary.

Refractive Index—Specific Gravity

The ultimate objective of the refractive index method is to arrive at an N_D figure translatable into terms of specific gravity or API gravity. In order to accomplish this, then, it is necessary to investigate the relationship existing between these two physical criteria.

The index of refraction of petroleum oils can be said to be inversely proportional to the number of volatile constituents present. In other words, the refractive index generally increases with a decreasing ratio of fractions with low boiling points. For example, N_D of ordinary gasoline is ± 1.41, of average kerosine ± 1.44, of light lubes ± 1.48. and of asphaltic residium up to ± 1.60. This relationship pretty well follows in parallel that of the specific density of these cuts from the refinery flow-sheet. A general correspondence between refractive index and gravity of liquid petroleum hydrocarbons, therefore, can be expected. Moreover, empirical data confirm a practicable linear relationship as is shown on the accompanying graph. By taking the refractive index of an oil from a core and then converting the reading to gravity using a calibrated graph for the particular field, it should be possible to do so with an accuracy of ± 2 deg of the measured gravity of the oil produced by the refinery.

Both Hedberg (1937) and Refshauge (1951), in determining the specific gravities of oil from the Maracaibo basin by means of refractive indices, arrived at relationships approximately linear. In plotting their values on rectangular graph paper, an "average" line drawn through their points coincided very closely in slope and position with a line connecting the plotted points of the aliphatics pentane through decane. Other previous investigators, as cited by Hedberg (1937), have found substantially the same approximation to a uniformly proportional decrease in refractive index with increasing API gravity (or decreasing specific gravity).

Fig. 1 shows the exactly linear relationship between the index of refraction and the specific gravity of the paraffin series light hydrocarbons, ranging from H_7C_{12} through $H_{10}C_{22}$ (see Table 1). This graph is included as a working relationship that can be generally employed until a local curve is calibrated for the producing areas in the field. Inasmuch as the refractive index of petroleum fractions varies with the type of prevailing hydrocarbons and mixed compounds present, it should not be expected that the gravity and N_D values for sweet crudes will plot exactly in line with values that have a high H_2S content.

With reference again to Fig. 1 it will be observed that specific gravity rather than API was plotted against refractive

TABLE 1[3]

HnC_{2n+2}	Sp. Gr. 60 F	API deg.	N_D 20 C	B.P. deg. C 760 mm
Pentane.....	0.621	92.7	1.357	36.2
Hexane.....	0.660	82.9	1.375	69.0
Heptane.....	0.684	74.4	1.387	98.4
Octane.....	0.704	69.5	1.397	125.8
Monane.....	0.718	65.6	1.405	150.7
Decane.....	0.730	62.3	1.412	174.0

index. This was done because specific gravity is fundamentally more meaningful in the laboratory, although API gravity may be more quotable in oilfield nomenclature. There are many excellent tables in petroleum engineering and refinery handbooks that allow ready conversion. The relationship between the two gravities is as follows:

$$\text{API}^\circ = \frac{141.5}{\text{Sp. Gr. @ } 60^\circ\text{F}} - 131.5$$

Advantages of Pre-Production Gravities

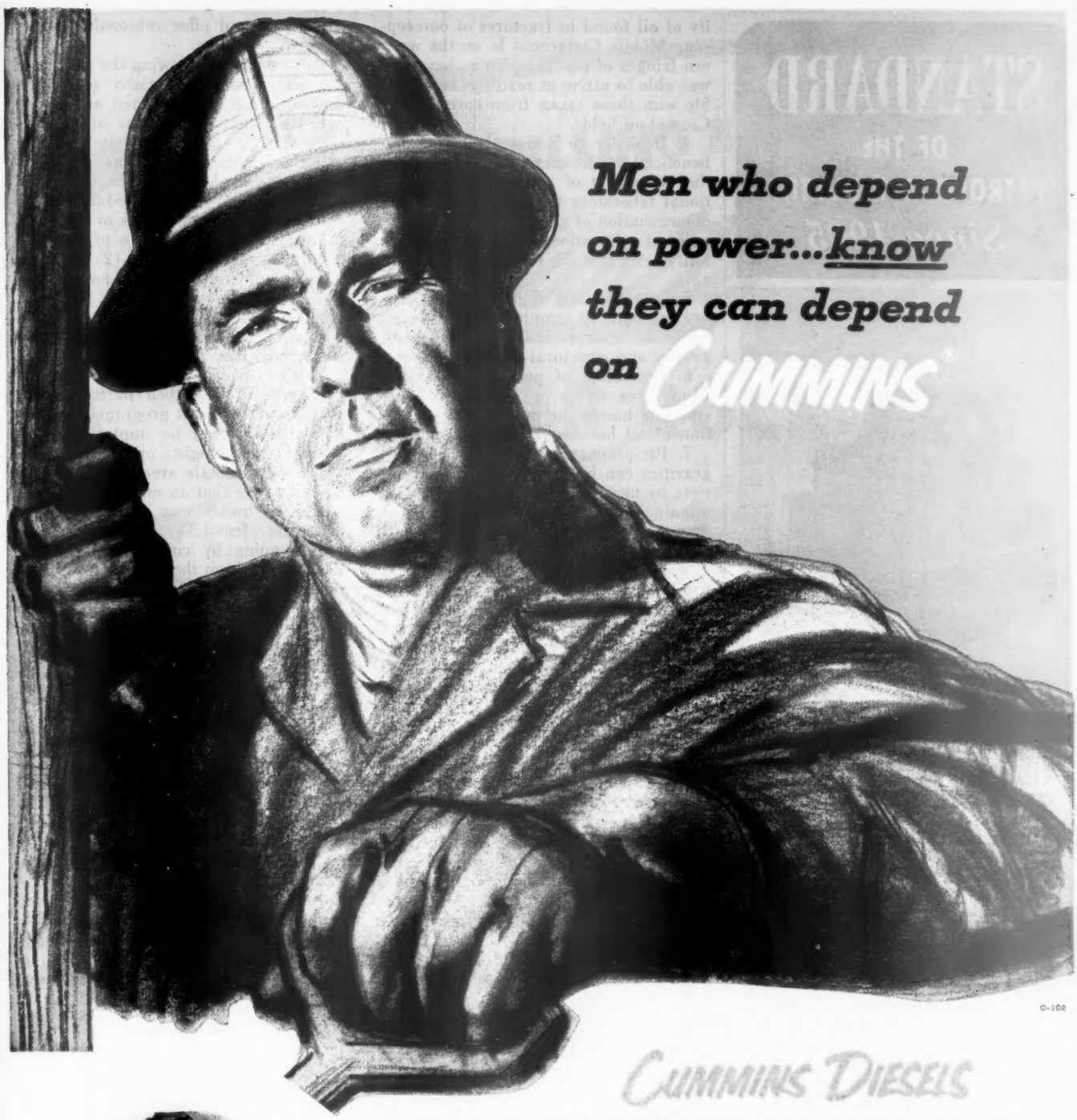
The advantages of determining the gravity of a crude (1) before the well has been completed, or (2) before the well is produced, are as significant economically as they are academically. Some attempt to enumerate and substantiate some of these advantages in summary fashion is presented herewith:

1. For the purpose of obtaining additional insight that the study of lithologic samples and fossils might offer to the paleo-ecologic factors under which a particular reservoir or source bed was deposited, the gravity of the contained petroleum can possibly be found helpful as a criterion. A few studies have been made with reference to the possible ways in which facies changes in sediments have influenced oil gravities. Donald C. Barton and others in the past propounded the time honored theory that under normal conditions the gravity of petroleum varied generally with the age of the buried source beds, the lighter oils being found in older beds This, of course, assumed that under the laws of superposition and uniformitarianism contributing conditions for higher distillation of petroleum such as greater depths, compaction, temperatures, and pressures would be present. More recent studies have supplemented this thinking with disclosures that the variation in the physical-chemical nature of petroleum is more specifically a function of facies changes within a considered time span (i.e., whether source bed materials were deposited, say, under neritic or bathyl conditions, determining thereby relative differences in indigenous petroleum gravities of oils contemporaneously generated).

2. Knowledge of oil gravities may prove very helpful in the correlation of oil-bearing strata in an area during the course of drilling or before completion of the well.

3. By the same token, these gravities are valuable for the identification of oils of similar provenance. As a case in point, Nigra (1951), in taking the grav-

[3]Physical Constants (except A.P.I. conversions) from *Handbook of Physics and Chemistry*, 22nd edition, Chemical Rubber Publishing Company, Cleveland, Ohio (1950).



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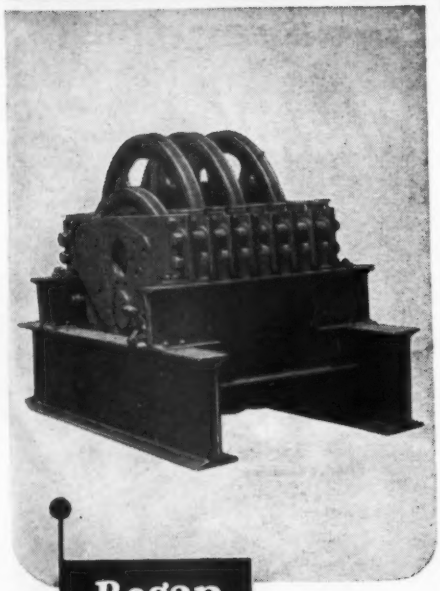

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ity of oil found in fractures of outcropping Middle Cretaceous ls. on the western fringes of the Tampico embayment, was able to arrive at readings comparable with those taken from cores in the Coastal oil fields.

4. In order to derive the maximum beneficial use from cores, it follows that the investment of relatively little additional laboratory time and cost for the determination of gravities as well as degree of saturation, porosity, permeability, etc., should be highly warrantable.

5. Determination of gravities from oil-bearing outcrop samples may aid materially in interpretation of the stratigraphy and structural geology involved.

6. Derivation of petroleum gravities from cores serves to "fingerprint" the core and hasten the preliminary evaluation of oil horizons during drilling.

7. Pre-production information on oil gravities can be gathered from drilling tests by usual methods; but, when only minute quantities of oil (such as that extractable from cores and sidewall samples) are available, one or the other of two methods described in this report can be used. As has been indicated, however, fairly close results can be obtained by these methods.

8. Rapid and fairly reliable estimates of oil quality before completion of the well may prevent passing up valuable sands and oil-bearing limestones, thus also preventing wasting time in testing relatively worthless sections.

9. By having a reasonably good idea of the gravity "spread" throughout the columnar section (i.e., of the vertical distribution of oil quality), the well geologist and engineer are armed with a valuable tool for making decisions on possible modes of completing the well after drilling (casing programs, types of strings to run, cementing techniques, position of the shoe, kinds of packers to use, which formations to test or to cement off, whether or not to produce in open hole, need for shooting or acidizing, gun perforation, etc.).

10. Knowing the relative gravities of the petroleum oils occurring in the penetrated horizons would enable discriminatory selection and segregation of the crude in the course of drillstem or later production tests.

11. A factor often ignored in the production of crude is that of refinery qualities and yields control. If by a selective well-completion and development program it is possible to produce, store, and transport petroleum oils having controlled gravities (taken as a handy index of oil quality,) then the likelihood of "quality give away" to the refinery is eliminated.

Conclusions and Recommendations

Determination of gravities from oil-bearing cores right after they are taken in a drilling well is not only feasible, but also highly advantageous. Two methods utilizing minute quantities of oil can be employed for these determinations: Water-alcohol suspension method and the refractive index method. They both involve relatively little cost, are rapid, and offer reasonably accurate gravity results.

Advantages of knowing the gravity of the oil in each potentially productive horizon, as it is penetrated and cored, can be evaluated in terms of exploration, drilling, production, and refining criteria. Instead of waiting for wellhead tests to determine the quality of the oil or oils being produced, it is economically advantageous to recognize it in advance for the sake of (1) corroborating geologic data, (2) deciding a well-completion program, and (3) allowing possible oil zone and, therefore, oil quality segregation in accordance with current refinery and crude marketing requirements.

Utilization of methods for determining gravities described in this report will allow a low cost program of investigation that could be implemented by one or two geologists or petroleum engineers in a single area. It is assumed by the writer that an engineering study would be under way to evaluate the economic feasibility of segregating crudes going by common facilities to the refinery from the particular oil field being considered. These oils would be those having an appreciably higher sulfur content, lower kerosine yield, and lower gravities, etc. A core-oil gravity research plan, having immediate as well as long-range objectives and value, could readily be organized and coordinated with such a study.

Acknowledgment

Information contained in this paper has been presented objectively and without specific reference to any company's restricted data.

Thanks are due to Dr. R. A. Bramkamp for suggesting this study; also, to Bernard Refshauge for his helpful and illuminating discussion of mutual problems encountered on a similar project he carried out in Venezuela, and on which unfortunately there has been nothing publically published.

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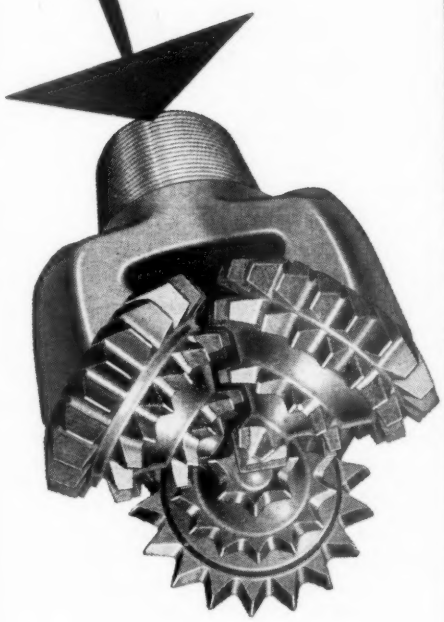

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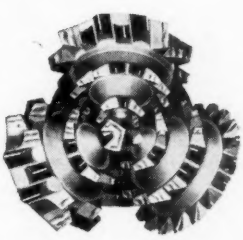

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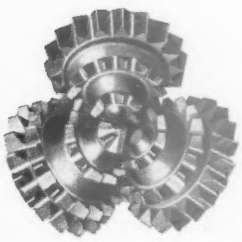

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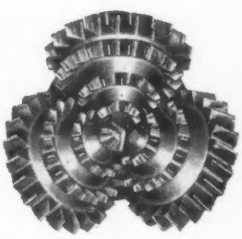

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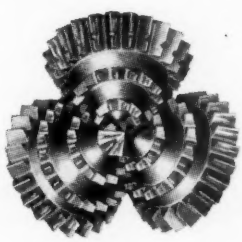

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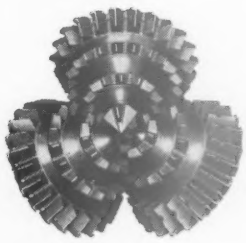
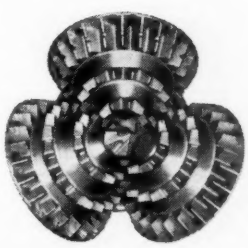


Type **H7L** For drilling hard formations. Used in hard formations such as lime, shale and anhydrite where some extra amount of gage protection is necessary.



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The Calibration of Gamma Ray Logs

Quantitative calibration of gamma ray logs increases their value in porosity evaluation of shaly sands

A. BLANCHARD* and J. T. DEWAN*

The following paper describes the calibration of gamma ray logs in terms of actual formation radioactivities expressed as the number of micrograms of radium-equivalent per ton of formation. The method by which this calibration is carried out is described and departure curves are presented which permit correction for the absorption due to mud, casing and cement in the borehole.

ALTHOUGH gamma ray logs have been run commercially for many years and have found widespread use in the oil industry, there has been little done, up to the present time, towards calibration of these logs in terms of formation radioactivities. The reason lies in the fact that the logs have been used exclusively for correlation purposes in the past. Recently, however, new uses have been found for the gamma ray instrument and these necessitate quantitative calibration of the logs.

For example, the gamma ray logging sonde is an excellent and ready-made tool for the detection of economically valuable deposits of uranium and potash. In fact, the Atomic Energy Commission recently asked, through the AAPG Advisory Committee on Radioactive Mineral Exploration,[1] that the oil companies inform the Commission of all formations which appear to contain more than 0.01 per cent of uranium, as indicated by gamma ray logs. Borehole conditions, however, and types of gamma ray equipment vary so widely that it is difficult to deduce accurately the uranium content of a radioactive bed without having a previous calibration of the log and a method of correcting for borehole variations.

Of more direct interest to the oil industry, however, is the possibility of using a calibrated gamma ray log, in conjunction with the neutron log, to evaluate the porosities of shaly sands. As pointed out in a succeeding article†, the neutron log is an excellent indicator of porosity in shale-free formations, but in shaly formations it responds also to the water, which is bound, chemically or otherwise, in the shale. Because of this it is necessary to correct the neutron deflections for the amount of shale present, in order to estimate the effective porosity. The gamma log could provide a source of data for this correction assuming, of course, a fixed relation between the shale content of a formation and its radioactivity. Such a relation, while not universally true, may hold in formations of the same geological age within given areas. In any event, a true evaluation of the method cannot be made until there are available gamma ray logs calibrated in terms of formation radioactivities.

For these and other reasons, a program of calibrating gamma ray logs has been introduced. This paper outlines our choice of a suitable calibration unit, describes method of calibration and presents departure curves to be used with this calibration.

Calibration Unit

Considerable thought was given to the choice of a suitable unit for scaling gamma ray logs. There are a number of possibilities. The one finally decided upon was the equivalent concentration of radium expressed in micrograms per metric ton of formation. This choice was based on the following considerations:

Natural gamma rays in the earth originate, directly or indirectly, from the three radioactive elements: Uranium, thorium, and potassium. Ultimate information that a gamma ray log could possibly yield, therefore, is the concentration of each of these elements in the formation. Normal well logging equipment, however, does not distinguish the gamma rays of one element from those of the others so that the maximum information obtainable from a gamma ray log is the equivalent amount of one of these elements. As uranium is the most familiar of the radioactive elements it would be logical to express the formation radioactivities in terms of equivalent uranium concentration.

This unit, however, is very close to one that has been in common geologic use for many years, namely, the equivalent radium concentration. Radium is an intermediate member of the radioactive series through which uranium decays to stable lead, and because of this genetic relationship, there is a fixed ratio between the amount of each in the earth. Specifically, the number of grams of uranium per unit weight of formation = 3.0×10^6 times the number of grams of radium per unit weight. Formation radioactivities can therefore be expressed equally well in terms of equivalent radium concentration.

The radioactivities of common sedimentary rocks, as determined from analysis of cores, are shown in Table 1.

TABLE 1.

Type of formation	Equivalent radium content in 10^{-12} gm/gm
Anhydrite, salt	0—2
Sandstone, limestone	1—10
Shaly sandstone & limestone	3—14
Light shale	5—20
Organic marine shale	10—90
Bentonite, volcanic ash	7—30

This table, taken from work published by Russell,[2] shows that the range of radioactivity most frequently encountered in a borehole is from 1 to 20 x 10^{-12} grams of radium-equivalent per gram of rock. This range can be expressed more conveniently as 1 to 20 micrograms of radium equivalent per metric ton of formation (1 metric ton = 10^6 grams = 2200 lb). Consequently, the unit that has been adopted for gamma ray calibration is the microgram of radium-equivalent per ton of formation, hereafter written μg Ra-eq/ton. In these units, full scale deflection on the gamma ray log will usually be between 5 and 20.

It is worthwhile pointing out that a calibration in terms of radium-equivalent *per unit weight* is more logical than one in terms of radium-equivalent *per unit volume*, as the former unit eliminates the necessity of taking into account the density of the formation. For instance, a cubic foot of dense material containing a given radium-equivalent per ton will emit more gamma rays than a less dense material containing the same radium-equivalent per ton, but it will also absorb more gamma rays and the two effects cancel, at least to a first order. This is borne out both in theory and by experiment.

True and Apparent Radioactivities

As the response of a gamma ray detector opposite a given formation will depend not only on the formation radioactivity, but also on the size of the borehole, weight of the mud, thickness of

*Schlumberger Well Surveying Corporation, Houston, Texas.

†Experimental Basis for Neutron Logging Interpretation" by J. T. Dewan and L. A. Allaud, will be published soon.

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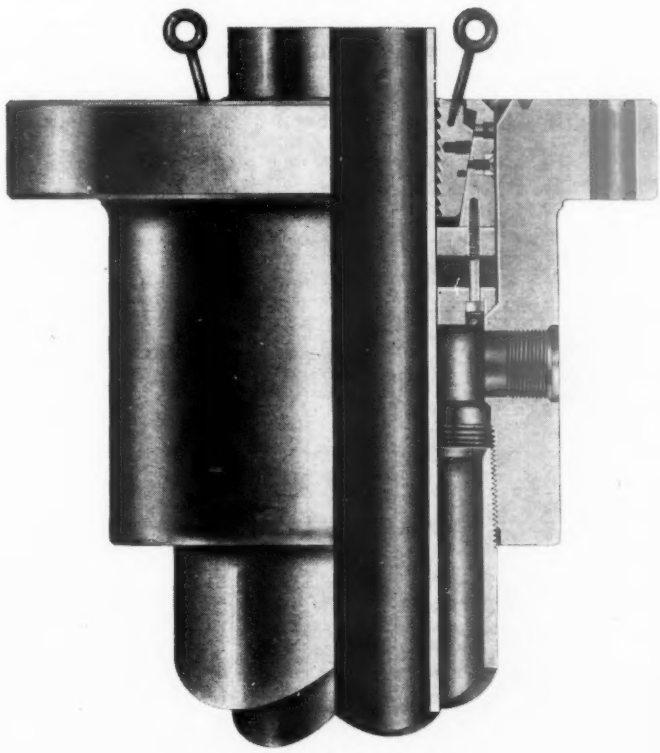

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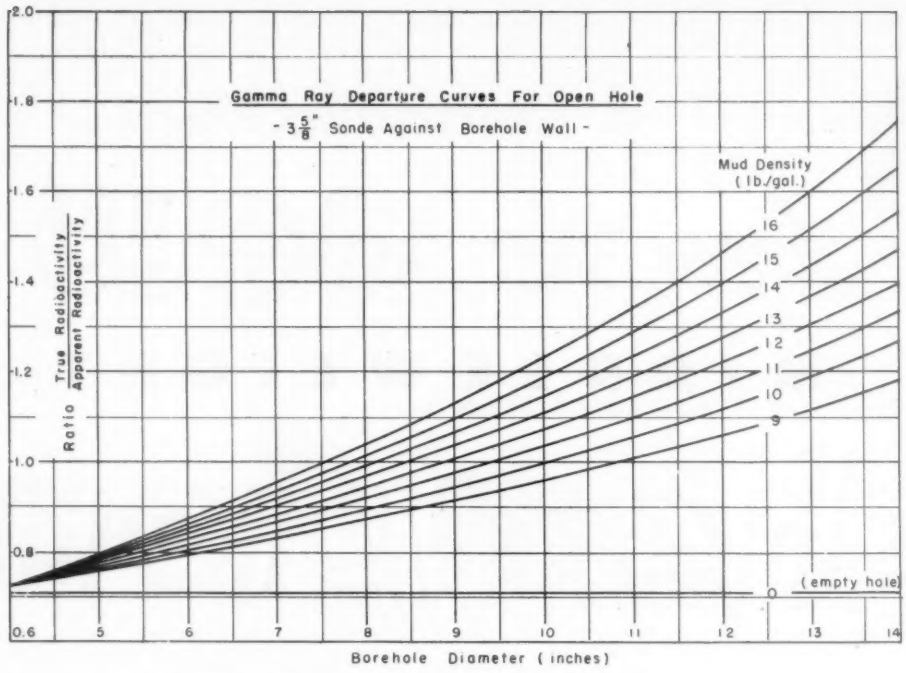


FIG. 1. Gamma ray departure curves for open hole.

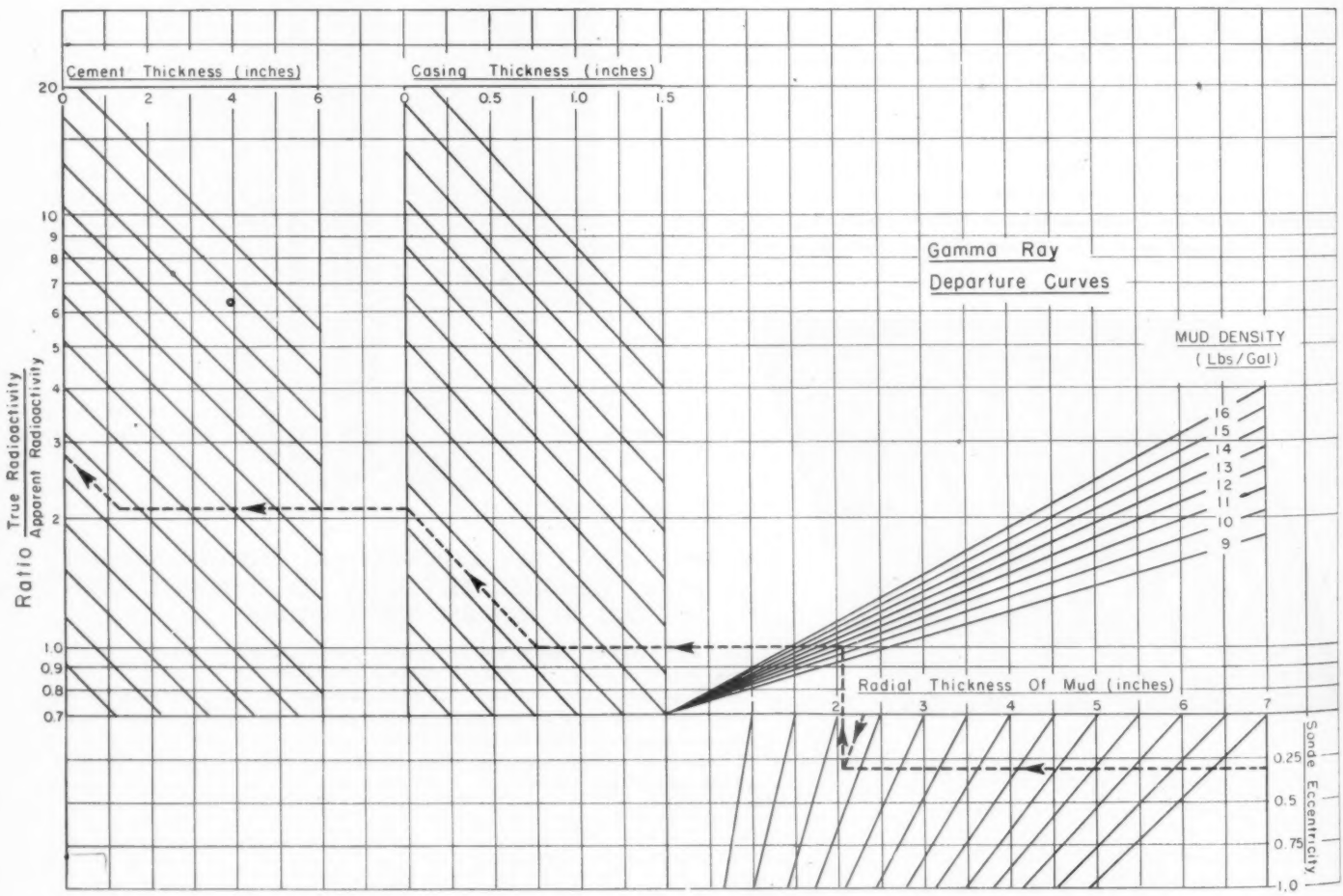
casing, etc. the gamma ray log in general will not indicate directly the true radium-equivalent concentration but an apparent value, analogous to the apparent resistivity in electrical logging. A calibration procedure has been adopted, however, under one specific set of conditions, such that the gamma ray log will indicate directly the true formation radioactivities. These "standard" conditions have been chosen to be: a 3⅝ in. OD sonde logging eccentrically (i.e. against the borehole wall) in a 10 in. diameter uncased hole containing nonradioactive mud of density 10 lb/gal. For all other borehole conditions and sonde diameters, it is necessary to refer to departure curves to obtain the true formation radioactivities from the apparent values shown on the log.

Method of Calibration

One of the prime requisites of a log calibration is to make the log deflections independent of the particular sonde or recording panel which is used. In order to do so, it is necessary, for gamma ray equipment, to use as a standard a small capsule containing an accurately controlled amount of radioactive material, usually radium. Immediately preceding the recording of a log this standard source is placed a predetermined distance "D" from the sonde and the resulting deflection of the recorder adjusted to a specified value. It is obvious that this procedure compensates for either small variations between nominally identical equipments or large variations between sondes of different sizes or efficiencies.

The value of "D" has been chosen to conform with the specification that the log must show directly the true radioactivity under the "standard" conditions previously defined. Accordingly, an artificial formation was set up containing a known concentration of radium and

FIG. 2. Gamma ray departure curves that take into account five parameters.



having standard borehole conditions. The gamma ray response due to this known radium concentration was determined, whence it was possible to choose the value of "D" such that a standard source, spaced this distance from the sonde, produced a response equivalent to a formation containing 10 μg Ra-eq/ton under standard conditions.

In order to calibrate a gamma ray log prior to a survey a field engineer merely places a standard test source "D" inches from his sonde, adjusts the resultant recorder deflection to half scale, full scale or twice full scale, etc., according to the radioactivity of the formations to be logged, and scales this deflection as 10 μg Ra-eq/ton.

Departure Curves

In general, a log is not run under "standard" borehole conditions, and it is necessary to refer to departure curves to obtain the true radioactivities from the apparent ones shown on the logs. These departure curves take into account the following parameters: Borehole size, sonde diameter, density of the mud, thickness of casing and cement, radioactivity of the mud and cement, and finally the position of the sonde with respect to the borehole wall (the sonde "eccentricity"). A considerable amount of experimental work was done to determine the effects of these variables, using artificial test pits in which the borehole conditions could be altered at will.

Fig. 1 shows the departure curves for the simple case of an uncased hole logged with a 3⅝ in. sonde, assumed to ride against the borehole wall. The borehole size is plotted as abscissa and the ratio of true to apparent radioactivity as ordinate. It is seen that, for the usual hole sizes (6 to 10 in.) and mud weights (9 to 11 lb), the correction factor is between 0.8 and 1.1, which is not a large range. For 10 lb mud and 10 in. hole no correction is necessary, as these were the normalizing conditions for the calibration. It is of interest to note that in the case of a dry hole (mud weight = 0 lb) the borehole size has no effect; the true radioactivity will always be 0.7 times the apparent value.

Fig. 2 shows the complete departure curves that take into account five parameters. From these curves the effects of borehole diameter up to about 18 in., mud weight up to 16 lb per gallon, casing thickness to 1.5 in. and cement thickness to 6 in. can be taken into account. Of the parameters which are plotted, only the sonde eccentricity needs explanation. Our experiments have shown that a given formation will give a greater deflection if the sonde is against the borehole wall than when it is centralized. For large holes the difference is appreciable. While in practice the sonde is never axial, this condition might be approached, for instance, in the case of logging a small bore hole which suddenly expands into a large diameter cave too short in length to allow the sonde to follow the wall contour. Another case is that of a sonde inside a small casing that is centralized in a large hole. It is assumed that the sonde always rides against the wall of the innermost casing and therefore the sonde eccentricity has been defined as:

$$\frac{d_c - d_s}{d - d_s}$$

where d_c is the ID of the smallest casing, d_s is the sonde diameter and d is the borehole diameter. Thus the eccentricity equals zero for a centered sonde and equals unity for a sonde against the formation wall.

In Fig. 2 the average radial thickness of mud has been plotted as abscissa rather than the borehole diameter. This automatically takes care of different sonde diameters and also allows for the displacement of mud by casing and cement. The curves have been extended to radial mud thickness of 7 in. in order to allow estimation of the effects of shallow caves.

As an example of the use of the departure curves consider the case of a 12¼ in. hole containing 11 lb mud and with 9⅝ in. and 7 in. OD casings, the larger one being cemented. The thickness of each casing is assumed to be ⅜ in. and the diameter of the sonde 3⅝ in. Average mud thickness, cement thickness, and sonde eccentricity are computed as follows:

Mud thickness = ½ (9⅝ — 2 x ¾ — 3⅝) = 2¼ in.

Cement thickness = ½ (12¼ — 9⅝) = 1-5/16 in.

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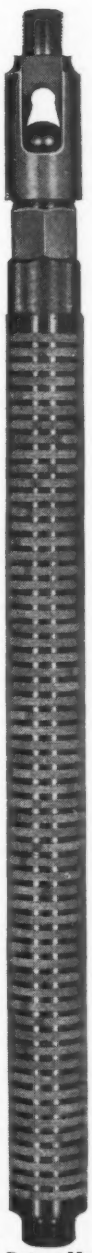

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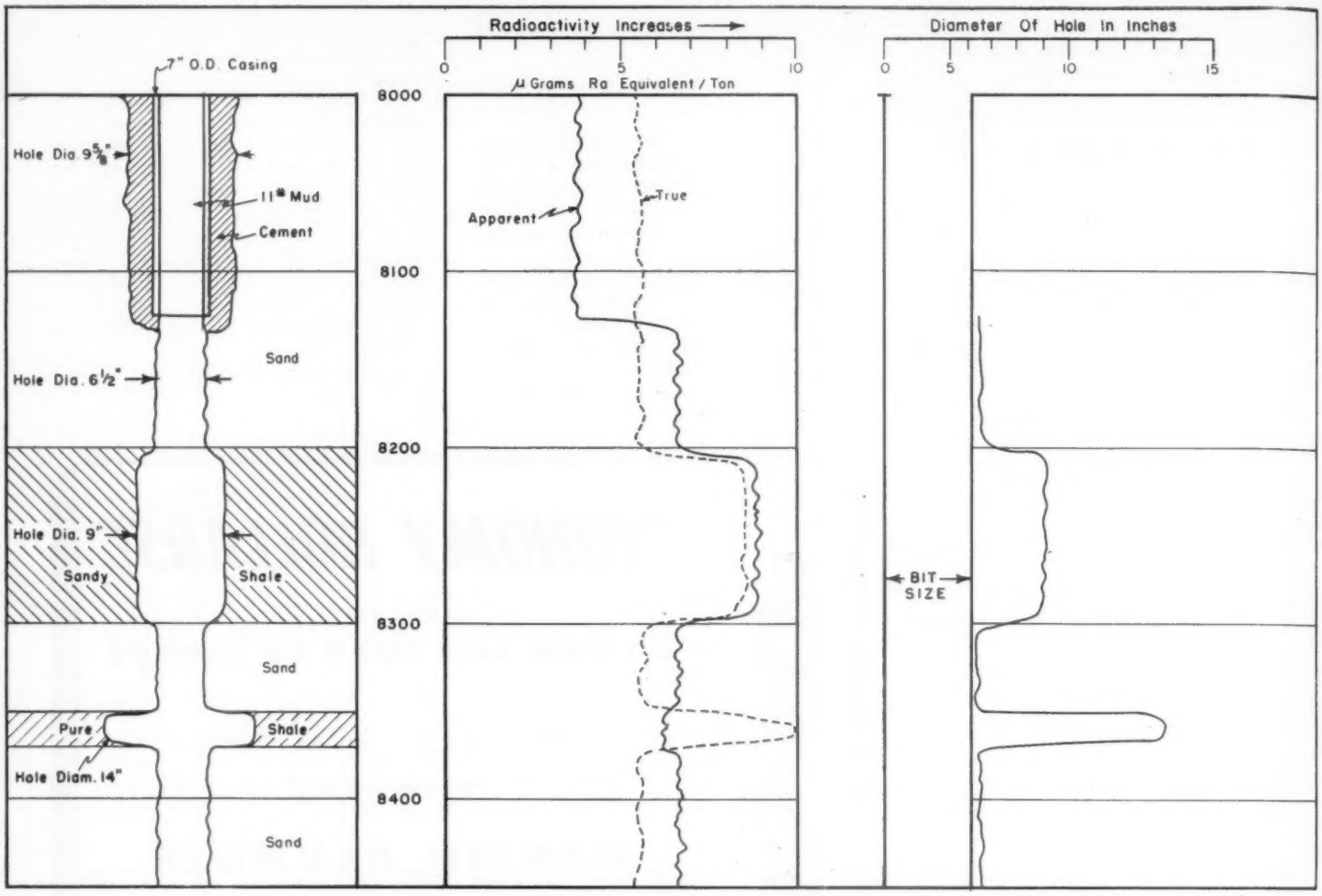

FIG. 3. Effect of casing, cement, and hole size on apparent radioactivity.

$$\text{Sonde eccentricity} = \frac{6\frac{1}{4} - 3\frac{5}{8}}{12\frac{1}{4} - 3\frac{5}{8}} = 0.30$$

Mud thickness (2¼ in.) and sonde eccentricity (0.30) are first inserted in the departure curves as shown by the dotted line. The intersection of these values is followed vertically to the appropriate mud weight (11 lb) and this intersection followed horizontally to the casing thickness (¾ in.) From this point the sloping guide lines are followed to zero casing thickness, thence horizontally to the cement thickness (1-5/16 in.) and finally along the guide lines to the desired ratio of true to apparent radioactivity which is 2.8. In this case then, the true radium-equivalent concentration would be 2.8 times the value shown on the log. Departure curves of Fig. 2 have been plotted in such a manner that if there is no casing or cement, the point of intersection with the mud density line is followed straight across to the desired radio of true to apparent radioactivity.

The final two factors, mud and cement radioactivity, are not taken into account by the departure curves of Fig. 2. In a great many cases these factors are negligible but in certain instances they can be quite important, as for example when the cement contains carnotite or when large caves in very low activity formations are filled with radioactive clay-base mud. In these cases actual measurement of the radioactivity of a mud or cement sample is necessary before appropriate corrections can be made. If the thickness of the mud or cement layer is constant, the gamma ray log can be corrected simply by shifting the baseline but when the hole size varies the correction will also vary. A method of computing the correction factor as a function of mud thickness has been proposed[3] but further experimental work is required to check the theoretical values.

It should be emphasized that the absorption of gamma rays due to mud and cement cannot be accurately predicted by calculation because many of the gamma rays which are detected have been "scattered" at least once in these layers. Theoretical calculations, based on absorption coefficients which have been measured with small samples in which no multiple scattering occurs, invariably overestimate the absorption effect of the mud and cement layers.

Example of a Corrected Log

Fig. 3 shows a hypothetical example of a gamma ray log run through a short section of hole, part cased and part open. The apparent radioactivity (solid line) as logged by the instrument, shows four distinct levels of radioactivity with the upper shale bed seemingly much more radioactive than the lower. However, the true radioactivity (dotted line) as obtained by the application of the departure curves and the section gage readings, completely eliminates the shift in level due to the casing and cement and, more important, shows the lower shale to be in reality more radioactive than the upper one. The former showed a low apparent reading because of its deep caving. It was assumed, in this example, that the mud radioactivity was negligible.

Conclusion

In establishing a program of calibrating gamma ray logs a unit has been chosen, the radium-equivalent in micrograms per ton, which we believe is both more useful and more meaningful than the other units presently in use. This calibration should aid not only in the newer uses of gamma ray curves but also in the well-established methods of subsurface correlation. When used with the departure curves presented here, the calibration will permit immediate determination of the economic importance of a highly radioactive bed, since a uranium content of 0.01 per cent is equivalent to a radium concentration of 33 micrograms per ton.

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★ ★ ★

Automatic Control Equipment for Oil Field Installations†

Operators can insure adequate action at minimum cost through proper selection of controls

PAUL KING*

AUTOMATIC control is achieved through the application of devices that eliminate the necessity for manually starting or stopping something. They are also applicable as damage prevention devices in limiting temperature or pressure excesses.

Controls are usually applied to conserve manpower, or do the job better or as a protective device. All controls fall in one of two basic types. They either control a medium between two limits or they limit the medium to a predetermined high or low value.

Electrical controls, as we apply them are used to either limit or control, pressure, temperature, liquid level, flow, speed or time. Oil wells are often pumped by time control utilizing a time switch to start pumping at some specific time and continue pumping for a definite time. While this method is satisfactory with many operators there are others who would like to start pumping at some specific time and continue pumping so long as there is a continued flow of produced oil. Devices of different types to accomplish this cycle of operation are being experimented with but we do not know of any available device as yet. Someday before too long we hope to have this kind of a control at a price the operators are willing to pay.

Here we have a good example of the difference between a controlling and limiting device. The time switch, as presently used, is a control; it starts and also stops the pumping cycle. If and when we add a flow device, then the time switch will become a limit control; it will start but not stop pumping cycle. The flow switch will also be a limit device as its function will be to stop the pump only after the time switch has started it and then only when the well has pumped off.

All controlling devices and limit devices have differential and most controlling devices have an adjustable differential. The time switch we were just talking about has a differential, the time span between the starting and stopping of the pump. You can set this switch to pump a minimum cycle of perhaps 30 min or it may be set to pump a maximum cycle of perhaps 23½ hours. The control may be for pressure, temperature or any other medium but it still has differential because it is impossible to turn off and again turn on at the same point.

With limit devices differential is not always important and in most cases it is not necessary that the differential be adjustable.

To more clearly explain this point suppose we are pumping oil at 800 lb pressure and it is desired to install a limit switch on the discharge to protect our equipment against excessive pressure such as pumping against a closed gate. We would call this control a high pressure discharge control. Then we would want another control also on the discharge to stop our pump should a line rupture occur. This control we call a low pressure discharge control; even though we refer to these devices as controls neither of them perform a control function; they are both limit switches. In selecting these controls we must first consider our normal pressure of 800 lb and by rule of thumb the normal pressure should not exceed 60 to 70 per cent of the control's adjustable range. One manufacturer has just what we want, an adjustable range of 0-1500 lb with an adjustable differential. In fact this manufacturer has three controls that seem to be very similar except for minimum differential and price. One control priced at $68 has a 100 lb minimum differential, another at $84 has a 50 lb minimum differential and a third at $90 has a 12 lb minimum differential. For the high pressure control we select a setting of 900 lb which will be 100 lb above normal pressure. Is differential important here? No — when this control trips at 900 lb the pressure is going to drop considerably before we start up again so we can select the $68 control.

With the low pressure control we have a little different situation. We want exactly the same range because the control will be exposed to the same pressure. There is no way of knowing what pressure drop we may have from a line rupture; it entirely depends on the size of the rupture and its distance from the pump so in order to get maximum protection we will want to set this control as close to the normal operating pressure as possible. Suppose we decide on a 760 lb setting, then we have only 40 lb between this control setting and normal pressure. The function of this control is to stop the pump as the pressure drops and in order for the control to reset itself the normal pressure must exceed the cutout pressure a little more than the differential of the control. Since our $68 control has a 100 lb minimum differential, it would be necessary for the normal pressure to exceed 860 lb to reset that control and we only have 800 lb normal pressure so that control will not do. The same holds true with the $84 control but our $90 control having a 12 lb differential will reset itself as soon as the pressure exceeds 772 lb.

I have seen dozens of expensive close differential controls applied where differential was of no importance, on applications where the most inexpensive control would do exactly the same job. Don't pay a premium for close differential unless close differential is required. Controls are really inexpensive if they are properly selected.

You may have a liquid level application and there are many different types of level controls. It may be possible to handle your application with a control selling for $20 or another selling for $175. They will both do exactly what you want. The $175 device may be no better for your application than the $20 one but there are applications where you can't use anything but the $175 unit. That is what it was designed for. When in doubt consult a control specialist. They can usually think of a dozen different ways to solve your problem and will suggest the least expensive so long as it will provide the function you require and deliver long uninterrupted service.

In the matter of liquid level control there are three popular types of devices for on-off control. One is a float actuated switch of which there are many different designs. One is the floatless or induction relay type and the third is a pressure actuated device utilizing the static head pressure of a column of liquid. The floatless type can only be used on water or any liquid that will conduct electricity. It has the advantage of simplicity

†Presented at Petroleum Electric Power Association, Mayo Hotel, Tulsa, Oklahoma, October 1-3, 1952.

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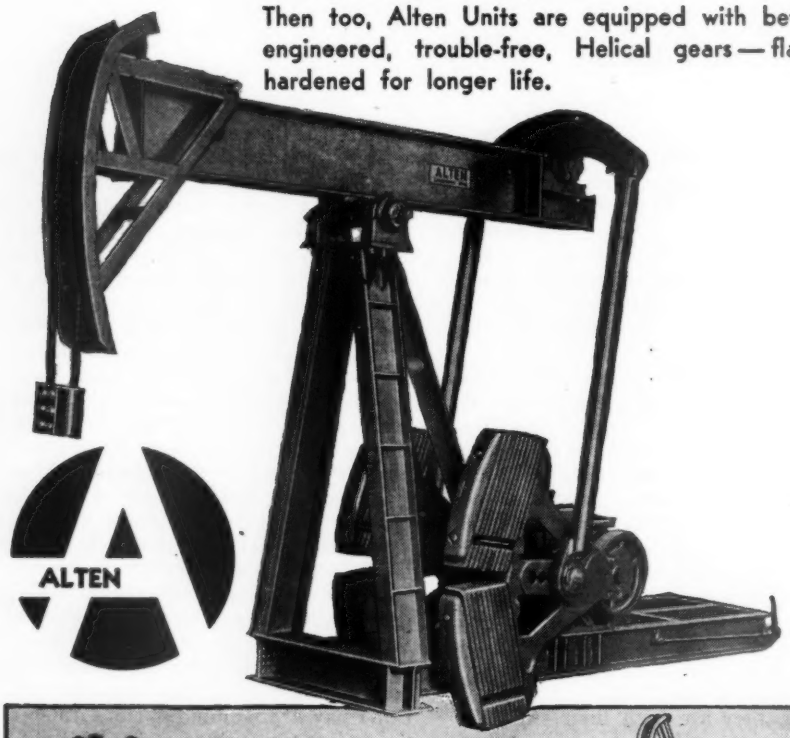

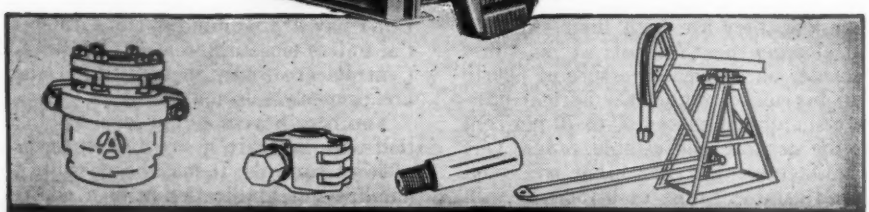

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and eliminates floats, rods, chains, cables and the various other methods of transmitting motion between a float and a switch. Where this type control can be used we favor it but as with all conrtols each type device has its own specific applications and it's only a matter of intelligent selection.

Too many people expect a control to function forever and without attention. Some controls do nearly that but any protective device, especially those that do not operate frequently, should be checked and inspected periodically. All sorts of things can foul them up, dust, corrosion, mud dobbers, and those little demons with 22's and air rifles.

Application of Controls

Production. The control of flowing wells by using a motor valve controlled by a time clock or a pressure control.

Automatic Tank Battery.

Pipe Line Stations

Floatless liquid level control for water tanks.

Float type liquid level control for fuel tanks.

Float type liquid level for sumps.

Float type level control for detection of excessive leakage of a pump seal.

Temperature limit switches for engine cooling water.

Temperature limit switches for lubricating oil.

Temperature limit switches for bearings.

Pressure limit switches for high pressure discharge.

Pressure limit switches for low pressure discharge.

Pressure limit switches for low suction pressure.

Pressure limit switch for loss of lubricating oil pressure.

Compressor Stations. Most of the applications just mentioned for pipe line stations will be found in compressor stations. In addition all suction scrubbers should be equipped with a float switch to protect against carrying liquid over into the suction. Many times there are applications for temperature limit devices in the discharge of the compressors to detect valve leakage.

Water Flood.

Floatless liquid level control for water supply pump.

Floatless liquid level control used as a low limit to prevent uncovering the suction at the water supply tank.

High pressure discharge control.

Low pressure discharge control.

Low lubricating oil pressure of the pump (or a rotary switch). ★ ★ ★

Oil men may be helped by "bugs" (micro-organisms) in their efforts to "squeeze" every drop of oil in an oil zone to the surface. If experiments in microbiological engineering are successful, the new system, using "bugs," food and enzymes, may hike the yield of oil fields in which secondary-recovery projects are being conducted.

"Emulsion" Zone Production

Successful completions in zones containing both oil and water increases Pariñas sand reserves

J. M. MARSH and E. L. ANDERS, JR.

The Pariñas sand of the La Brea-Pariñas Concession in Peru contains zones as thick as 250 ft which will produce both oil and salt water simultaneously from the same interval. Production of a mixture of the two fluids from the same zone caused them to be referred to as "emulsion" zones. These thick transition zones are present in only a few pools. Important commercial oil production has been obtained from the "emulsion" zones, and more will be produced in the future. So far no production has been obtained from these zones except in pressure maintained pools. Evidence indicates that the existence of these zones is probably due to tilting and faulting of the reservoirs in comparatively recent times and the subsequent adjustment of the fluid contacts.

THE sediments of the La Brea-Pariñas Concession are broken into myraid blocks by both major and minor faults. The Pariñas sand, which ranges in thickness up to 1000 ft, has produced oil in the central and northern parts of the Concession from many of these blocks seemingly regardless of depth or juxtaposition to wet blocks higher in structural elevation. It has produced about 70 per cent of the Concession's total oil production. Subsea depths to the top of productive Pariñas sand range from 200 to 7300 ft, and oil legs as thick as 600 feet have been encountered. Areal extent of individual Pariñas pools varies from a few to as many as 300 acres, and most of these pools consist of more than two reservoirs separated by faults. The sand dips at angles as high as 30 degrees, but the average is 15 to 20 deg. The productive blocks normally contain bottom water.

Discussion

"Emulsion" zone is the term commonly used on the Concession to identify the intervals within the Pariñas sand, which contain mobile water and commercially producible oil. Although the Pariñas sand has been under active development since 1913, the existence of "emulsion" zones has been recognized only since 1946, and the commercial possibilities were not proved until the beginning of 1948.

The older pools were drilled with cable tools. The normal practice was to establish a level at which some water would be produced and then to stop all wells above this level until development was completed or until another fault block was recognized. Later, with the adoption of rotary drilling and the single point resistance Blau-Gemmer log, the present practice of completely penetrating the sand in each well was made standard. Main reason for drilling through the sand was for structural information. It was then found that considerable trouble was sometimes experienced in making clean oil completions in zones that had good oil shows in the cuttings and looked favorable on the electric log. In a number of pools, practically every well was believed to have a bad cement job. Expensive and time consuming squeeze jobs either failed to shut off water or succeeded in completely shutting off everything.

One expedient that was adopted to overcome the "bad cement job" was to "shoot safe." This could be done in most pools because of the great thickness of the sand. Many of the pools, however, are broken up into two or more small reservoirs which often have different fluid contacts. "Shooting safe" in such cases often meant gun perforating above clean oil. After electric logs became available in Peru and more experience had been gained, it was concluded that some of the Pariñas sand pools did have extremely thick transition or "emulsion" zones from which commercial oil production could be obtained.

Section Sixteen Pool

Most of the wells in Section Sixteen pool were drilled with cable tools following standard completion practices of the time. In recent years, a deepening program to aid in draining the pool efficiently encountered zones which produced oil and water on tests throughout a considerable interval. Fortunately, all zones containing any oil shows were cased off, and the completion was made in the clean oil zones. Fig. 1 is a profile across a portion of the Section Sixteen pool which shows the relationship of the "emulsion" zone to the other fluid zones. About 250 feet of "emulsion" zone has been identified. The clean oil-"emulsion" contact in this pool varies in depth from about 1210 ft subsea to 1260 ft subsea in individual wells. Average dip of the Pariñas sand in this pool is 23 deg, and the dip is to the east.

The Mile Six pool lies immediately to the north of Section Sixteen and is downfaulted from it by about 900 ft. Whereas Section Sixteen originally contained an oil leg of 330 ft and an "emulsion" zone of 250 ft, Mile Six had an original oil leg of 565 ft and a normal transition zone of less than 30 ft. Both had initial free gas caps.

Pressure has been maintained at very close to its original value since the beginning of production in Section Sixteen pool. By January 1, 1948 it had produced 90 per cent of the estimated total 15,000,000 bbl of clean oil reserve, and almost all wells had gone to high gas-oil ratio. At that time a program of gun perforating was begun to open the zones that had tested oil and water. Fig. 2 is the production history of a typical re-completion in the "emulsion" zone. This well, number 2556, was producing about 20 bbl daily at a gas-oil ratio in excess of 4000 cu ft per bbl before it was recompleted in January 1950. After

The Authors

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E. L. Anders, Jr., is a chief reservoir engineer for International Petroleum Company, Ltd., at Talara, Peru. He was graduated from the University of Texas and has a MS degree from the Colorado School of Mines. He spent two years as an aviation fuels evaluation officer in the flight test section of the Navy, and upon discharge worked as reservoir engineer for Creole Petroleum Corporation in Caracas, Venezuela, for two years. From 1948 to 1951 he taught petroleum engineering at the University of Kansas, and in June of '51 joined International Petroleum.

J. M. Marsh

E. L. Anders

EXCLUSIVE

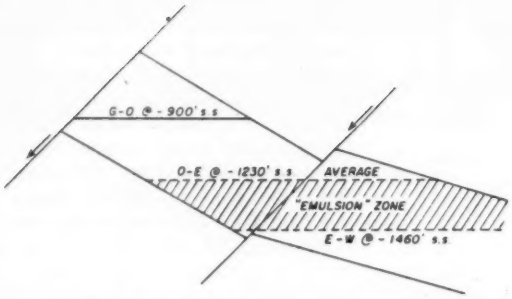

FIG. 1. Profile in section 16 pool showing "emulsion" zone.

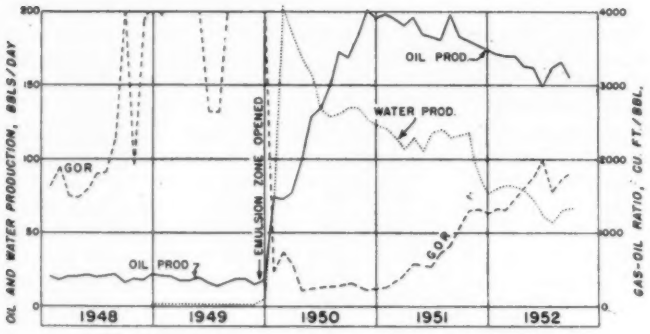

FIG. 2. Typical production history of re-completion in "emulsion" zone, well 2556—section 16 pool.

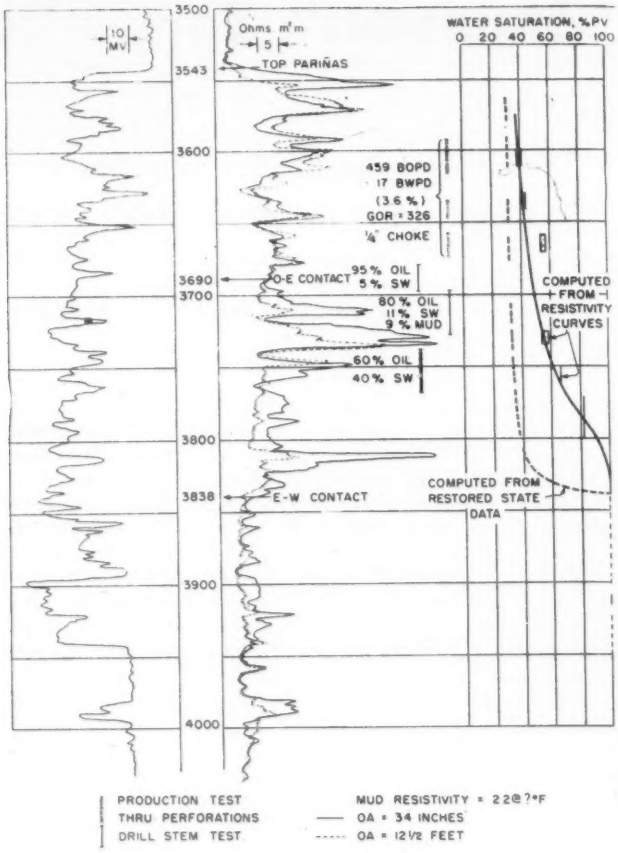

FIG. 3. Electric log of potential "emulsion" zone producer, well 3782—Silla pool.

the "emulsion" zone was opened, it began to produce at a rate of 74 bbl of oil and 200 bbl of water per day at gas-oil ratio of approximately 600 cu ft per barrel. Over the next ten months, the oil production gradually increased to 200 bbl daily, and the water production declined to 127 bbl per day. After that time, the oil production began to decline normally, and water production continued to decrease. The gas-oil ratio has gradually increased from 231 cu ft per barrel in April 1950 to 1825 cu ft per barrel in September 1952. Prior to January 1, 1948, the remaining reserve in Section Sixteen was estimated to be 1,300,000 bbl. To this reserve has been added 2,400,000 bbl of oil that can be produced economically because of the "emulsion" zone completions. In September 1952, oil production from the "emulsion" zone completions was 790 bbl daily as compared to 250 bbl from the remaining clean oil completions, and 1,215,000 bbl of oil had been produced from this zone.

At the same time that Section Sixteen pool was being tested, evaluation of possible "emulsion" zones in other pools was started. The electric log has proven to be especially valuable in this evaluation. Accumulated experience in interpretation of the logs in the field is such that it is usually possible to recognize an "emulsion" zone from the resistivity curves of the log.

As an example of an electrical log of an "emulsion" zone, Fig. 3 is presented. This log represented is of well 3782 in Silla pool, and it shows the information generally used to identify an "emulsion" zone. Both of the resistivity curves are of the lateral type, with spacing of 34 in. and 12 ft. Testing results are shown to the right of the resistivity curves. The sand produced 60 per cent oil and 40 per cent water through perforations at 3738 to 3768 ft. Previous open hole drill stem tests above this interval had shown higher oil cuts, and on final completion the well flowed 459 bbl of oil and 17 bbl of water (3.6 per cent) per day through a ¼ inch choke. The water disappeared when the production rate was cut back.

Quantitative estimates of water saturation as computed from the resistivity curves are shown to the right of the testing results. For comparison, water saturations calculated from restored state data are also shown. Near the top of the Pariñas section, the water saturations indicated by both procedures are essentially identical. As the zone of 100 per cent water saturation is approached, however, the two methods begin to give divergent results. This divergence indicates that static equilibrium does not exist and that the transition from 100 per cent water saturation to irreducible minimum saturation takes place over a much greater interval than could be predicted from the restored state data.

The actual transition zone in this case is about 148 ft thick where a thickness of only 40 ft would seem to be normal for the particular sand-fluid system.

Origin of the "Emulsion" Zones

Several explanations for the existence of these abnormally thick transition zones have been proposed, but none of them seem to be completely adequate.

The hypothesis that sand lenses containing mobile oil and immobile water alternate with lenses containing water only has been discarded because of the evidence gathered from electrical logs and numerous drill stem and production tests. Each permeable sand stringer within these "emulsion" zones contains both mobile oil and mobile water.

Tilting of the resorvoirs and the subsequent adjustment of fluid contacts in such recent times that static equilibrium has not been reached is one explanation. It is probable that there is still some adjusting within the areas where these zones are found, and it is quite likely that additional tilting of the reservoir beds has occurred with comparatively recent times (possibly Pliocene).

Movement of fluids from one block to another within a single pool after minor recent faulting occurred could also explain some of the anomalous conditions in some pools.

It is unlikely that any of the above theories alone can explain the occasional great thickness of the "emulsion" zone. A combination of recent tilting plus fluid movement between blocks after recent minor faulting within the pool probably can explain their existence, however. Geological evidence indicates that some tilting to give steeper dips has occurred, and there are numer-

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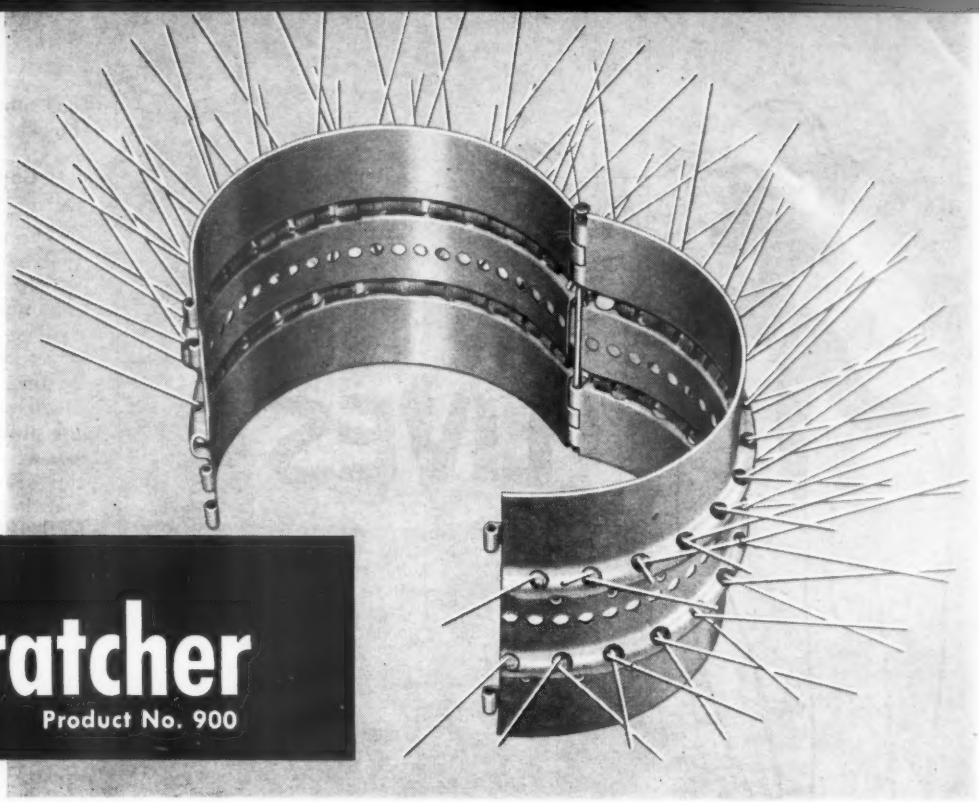

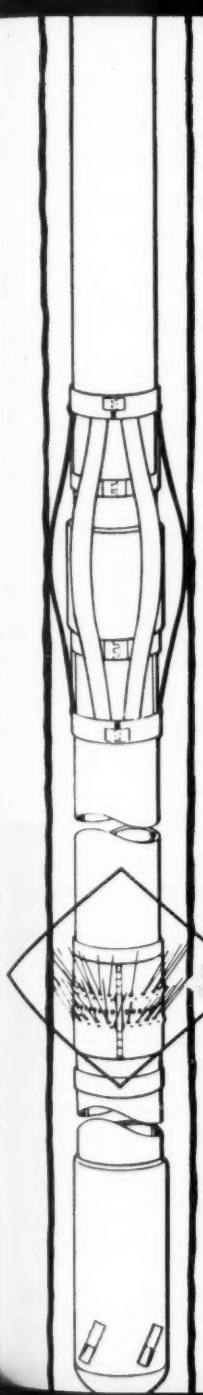

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Hinged for easy installation, the Baker Wall Scratcher is equipped with two full rows of sturdy, spring-loaded scratcher wires that give complete 360° scratching coverage. Each pair of wires is crossed for greater strength in cutting the wall cake into small particles.

The scratcher wires are pitched upward so that the scratcher can, first of all, be run to scratching depth without causing any significant disturbance of the mud cake. This feature is even more important during the actual hole-conditioning operation, because the up-pitched scratcher wires dig more firmly into the wall cake and are forced into a position of maximum reach and scratching efficiency whenever the casing is raised more than the distance between Stop Rings.

QUICK FACTS *about Baker Wall Scratchers*

1. Spring-loaded scratcher wires are pitched upward to dig firmly into mud cake with maximum reach and scratching efficiency on the upstroke during scratching operation.
2. During down-hole travel, up-pitched scratcher wires ride easily along surface of well bore and minimize scratching action.
3. Mud cake remains undisturbed until casing is raised more than distance between Stop Rings.
4. Scratchers reach scratching depth in good condition, with scratching efficiency unimpaired by excessive distortion of wires and springs.
5. Two rows of sturdy scratcher wires, crossed in pairs, assure full 360° scratching of more surface at each stroke; cut wall cake into smaller particles.
6. Scratcher wires are available in two lengths to meet the specific needs of slim-hole or regular programs.
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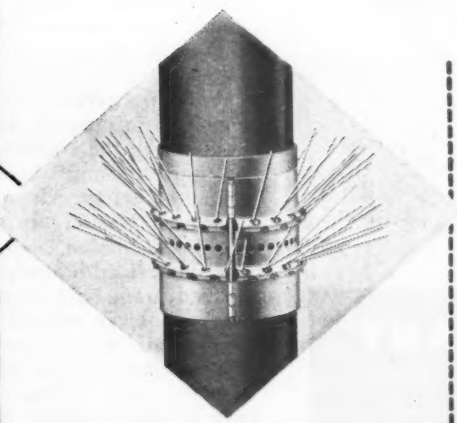
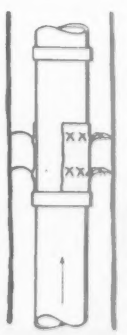


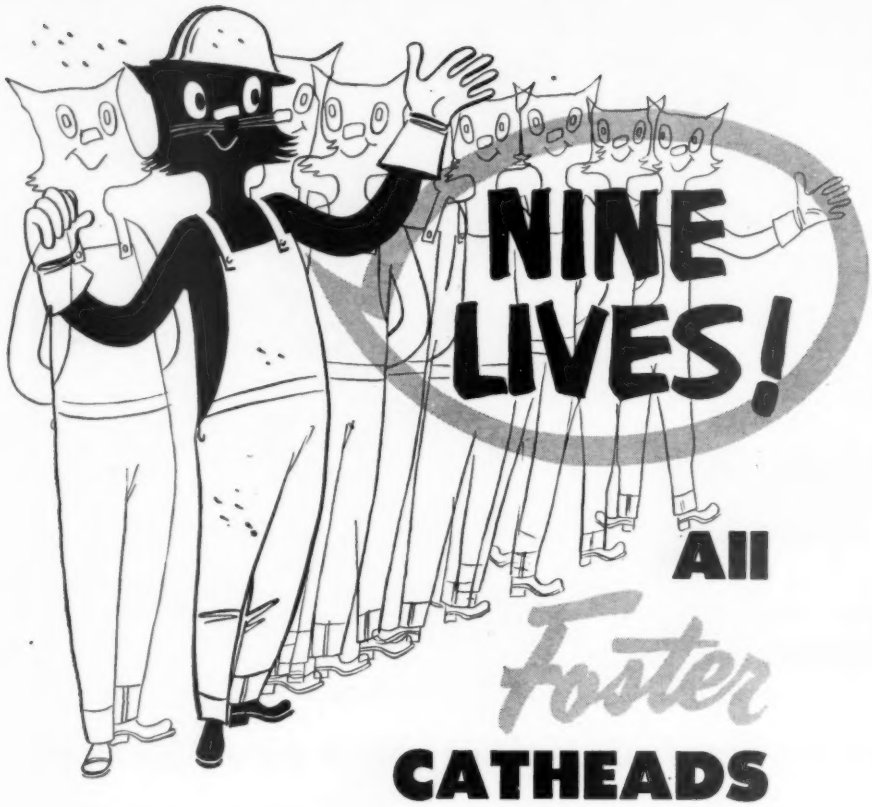
Here is how controlled scratching works →

During down-hole travel, the up-pitched scratcher wires ride easily along the surface of the well bore so that no significant disturbance of the mud cake will result.

When the casing is lifted up out of the slips during the running-in operation, no scratching action occurs. Scratcher remains stationary until contacted by Stop Rings.



On each upstroke during the actual scratching operation, the crossed pairs of up-pitched scratcher wires dig firmly into the mud cake with maximum reach and scratching efficiency.



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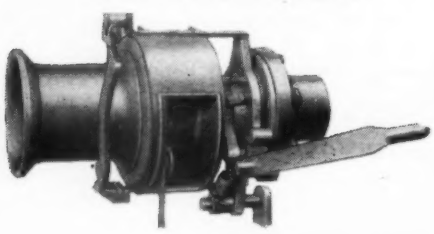

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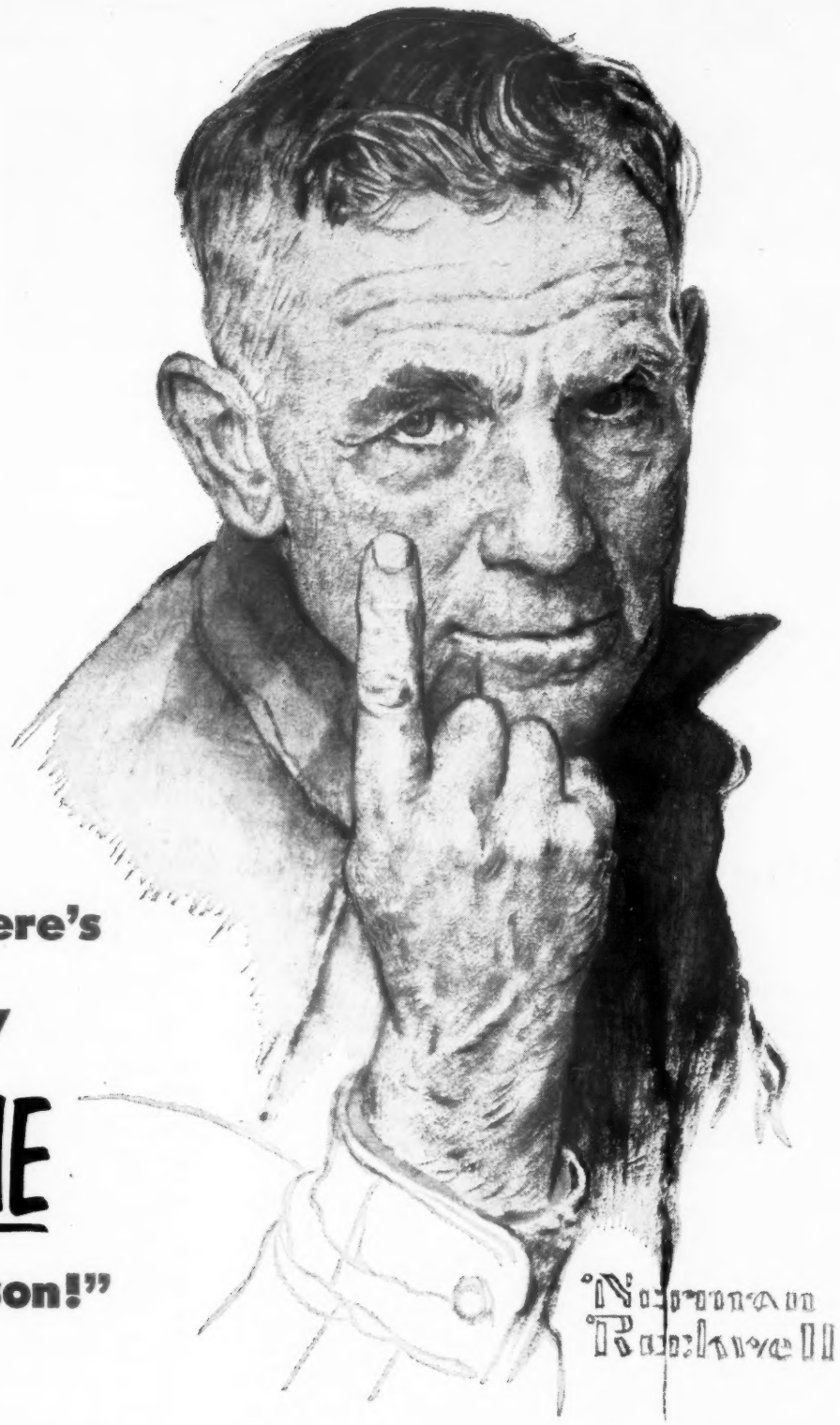
ous minor faults within the large fault blocks in all of these pools.

Completion and Production Problems

The practice in completing new wells that have "emulsion" zones is to establish the fluid contacts as accurately as possible by means of electrical logs, drill stem tests, and information from offset wells; and to run casing completely through the "emulsion" zone. The clean oil zone is then gun perforated for production. The "emulsion" zone is opened to production at such time as the clean oil zone becomes non-commercial or goes to high gas-oil ratio. In old wells, it is necessary either to squeeze off or to pack off the zones of high gas saturation prior to testing the "emulsion" zone. It is often necessary to pull liners and deepen these wells through the zone.

Testing of the "emulsion" zones in various pools has led to the conclusion that commercial oil is recoverable from these zones only if the pool has been pressure maintained effectively. All efforts to produce these zones in pressure depleted pools have failed to result in commercial wells. None of the pools that have these zones have effective natural water drive since the aquifers are of very limited extent. When a well is completed in an "emulsion" zone, certain water and oil saturations exist, and the effective permeability to each phase is determined by that saturation. As production of oil and water occurs, the water saturation is decreased because there is no effective replacement of water from the aquifer. If the reservoir pressure is still near its original value and effective gravity drainage exists, the oil saturation in the same zone will be increased. Thus, as production continues, the effective permeability to the oil phase increases as the effective permeability to water decreases. The effects of this change in effective permeabilities is shown clearly in Fig. 2 by the production curves. Since the perforations in the previous clean oil zone (now gas swept) are isolated by squeezing or packer settings after re-completion in an "emulsion" zone, the gas-oil ratio decreases sharply. The gas - oil ratio again increases after the gas-"emulsion" contact approaches the new perforations. This behavior is also shown in Fig. 2.

A re - completion technique is thus suggested in pressure maintained reservoirs where the transition zone is normal and thin and where the aquifer is of limited extent. After the oil zone becomes gas swept, open the transition zone to production. A significant amount of profitable additional oil might be recovered from such re-completions. Of course, a large amount of water must be handled in this case. It is possible that in some cases it will be necessary to pump large volumes of water with only a small amount of oil until the saturation and effective permeability conditions for large oil volumes can be established. ★ ★ ★



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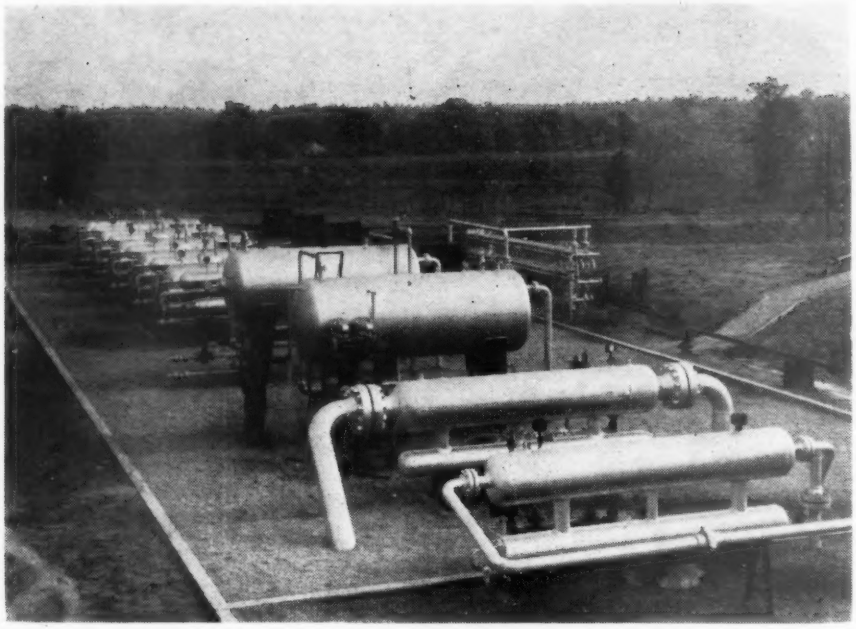

Largest gas installation in the Woodlawn field is operated by Stanolind Oil and Gas Company. It consists of two high pressure separators, two low pressure separators, five cold separation units set in line immediately downstream from 1900-lb separator, and a compressor unit to recover gas flashed from 250-lb separator.

Woodlawn Gas Field

This six-year-old East Texas field now developing into a major gas reserve

JACK L. WIGGINS

THE Woodlawn gas field lies just south of the Harrison-Marion county line in Harrison County. Although the majority of its wells are in Harrison County, at least two wells spill over into Marion County.. The field is primarily a gas field, but wells on the edge have a tendency to go to oil. Consequently, a few wells are equipped with emulsion-treating equipment and stock tanks. Mainly, however, the field's 33 wells are gas producers.

Production is primarily from the Pettit formation at depths around 6400 to 6500 ft. For example, the discovery well was shot for production at five different levels: 6366-72 ft; 6356-62 ft; 6376-79 ft; 6385-87 and 6390-6440. A total of 6884 ft of casing was set, although original depth of the wells was 10,374 ft, according to records of the Railroad Commission in Austin.

The discovery well, which was tested on October 28, 1947, was the Stanolind Oil and Gas Company's No. 1-A Slaughter, T. E. White survey. It had an initial reservoir pressure of 2080 psi, and a potential of 7,000,000 cu ft in 24 hours.

This discovery well was the only well drilled in the Woodlawn field during the year of 1947. No producers at all were drilled in 1948. Three producers were brought in in 1949: Stanolind's No. 1 Jones, Watkins Survey; Stanolind's No. 1 Highland Lake, Post Survey, and Stanolind's No. 1 Lake, White Survey. These wells had potentials of from 60,000,000 cu ft to 121,000,000 cu ft daily.

Eleven more wells were completed as producers by Stanolind in 1950. Potentials of these wells ranged from 960,000,000 cu ft on the Lake Fern No. 2, White Survey, to 365,000,000 cu ft daily on No. 1 Davis, Watkins Survey.

Unblocked acreage was acquired around the field, and in 1951 other companies than Stanolind had brought in producing wells. These companies completed six new producers during 1951. R. W. Fair completed the No. 2 Medine on the Bowman Survey; Hollandsworth Company completed three wells, the No. 1 Davis, Watkins, and Gray Survey; The No. 1 Davis, Watkins Survey, and the No. 1 Davis, J. Husbands Survey. Roger Lacy drilled the No. 1 Green, Fields Survey; Midstates brought in the No. 1 Bender, Holmans Survey. The Midstates well had a potential of 225,000,000 cu ft. Potentials of the other wells ranged from 6,000,000 to 50,000,000 cu ft daily.

R. W. Fair completed a second well in 1952 on the Davis lease, Holman Survey. The Stanolind completed four more wells during the year, two of them testing more than 300,000,000 cu ft in 24-hour potential tests.

At the present time the Kemp Oil Company has two wells in the field, both in Marion County. One of the Kemp wells is classed as an oil well.

Average production of the field over the past year is about 55,000,000 cu ft daily. Flowing well pressure is around 2200 psi. Average gas well production is about 3,000,000 cu ft daily. Flow temperature is approximately 120 F. Largest part of the gas is taken by the Mississippi River Fuel Corporation.

Stanolind Oil and Gas processes its raw gas by sending it through two horizontal separators and five cold separation units. A compressor station is used to repressure gas which flashes from the low pressure distillate line. Distillate and liquid hydrocarbons are stored. and dry gas is sent to the Mississippi system.

Proration of the field is based on demand shown by the producers and consequently its production varies with the weather. In the winter months demand and production are high, and conversely. production drops off in the summer when demand is low.

Shown in the photograph is the largest gas installation in the Woodlawn field. It is operated by the Stanolind Oil and Gas Company. It consists of two high pressure separators, two low pressure separators, five cold separation units set in line immediately downstream from the 1900-lb separator, and a compressor unit to recover gas flashed from the 250-lb separator. ★ ★ ★

The Author

Jack L. Wiggins is petroleum training specialist at the University of Texas, Division of Extension. He was graduated from the University of Texas in 1934 and worked in the East Texas oil field from that time until he joined J. B. Beaird's engineering department in 1942. From Beaird he went to Lion Chemical Corporation as a junior engineer, and in 1946 became an instructor for Dallas Vocational school. He accepted his present position in 1949.

EXCLUSIVE

Review of Techniques Used in Flooding Limestone Reservoirs in Tri-State Area†

Discussion of the possible injection methods applicable in secondary recovery from lime pays

LEON KRAUSE*

CONSIDERABLE emphasis has been placed on waterflooding sand reservoirs; however, some lime "pays" are worthy of consideration as potential sources of secondary reserves.

In general, results from flooding lime "pays" are not comparable in magnitude to the recoveries from sand reservoirs, but the intensity of development, the capital outlay, and the economics associated with the proposed project must be judged in terms of anticipated profit. As a rule, lime floods have an advantage in that a nominal capital investment is required to place this type of secondary recovery project in operation. Spacings ranging as high as 40 to 80 acres per input, and the conversion of present producers to injection wells reduce development costs to a nominal figure. High permeabilities, averaging in excess of 500 millidarcys, continuity of the porous zone over a large area, and the possibility of utilization of a high hydrostatic head enable the use of wide input spacing.

Favorable Lime Pays for Flooding

The type of lime pays that have waterflooded successfully are:

1. Oolitic, which is composed of spherical grains of calcium carbonate bonded with calcite. This type has physical characteristics similar to a sandstone.
2. Crystalline dolomites.
3. Calcareous sands or sandy "limes."

Technological progress has not advanced to the point wherein it is considered advisable to flood the vugular and fractured lime pays.

Engineering Study

Prior to initiating the flood, an engineering study should be made of the limestone reservoir in order to establish the identity and continuity of the pay zones in the formation. A structure map should be drawn on a well defined and blanket marker horizon. Wells tentatively chosen for conversion to injection should be selected to affect the largest number of producers surrounding the input. For example: If some wells are producing from the upper break, others from the lower, and a third possibly of both breaks, the selected input should service the largest number of producers in the area assigned to injection well.

Structural position is of importance because it has been proved from field operations that it is advantageous to place the injection wells on the flanks and move the oil up structure.

Wells chosen for inputs should have a good primary production history or a high injective capacity. An examination of the electric log, initial potential, cumulative recovery, and present production will assist in determining the ability of the well to take water. Wells drilled into edge water and possessing sufficient capacity can be utilized to supplement a natural water encroachment, if present. Occasionally, a mistake is made in attempting to convert tight edge wells to water inputs. The prerequisite of a flood is to get the repressuring media into the reservoir and this can only be accomplished by having good injection wells. Tight wells will function better as producers than inputs in a flood.

The ideal injection pattern for a limestone reservoir is to have widely spaced input wells on the flanks of the structure. The time required to cause migration toward the dome is longer than the period necessary to obtain an increase from a more intense spacing. Results of studies, however, indicate that flank drives are more efficient and operating costs are less. In order that full advantage may be taken of this flank injection efficiency, it is generally necessary to unitize leases because of the strategic locations of the wells which in turn would cause movement of oil across property lines. Common factors for participation formulae are cumulative recovery, present daily production, and number of wells.

Means of Injection

Various modes of injection have been utilized in flooding the limestone reservoirs. The oldest and cheapest method of injection is called the "dump" flood. Pumping equipment is removed from the well, the casing opposite a water sand is ripped or perforated, and the brine pours down the casing into the "pay" under gravity or the hydrostatic head exerted by the water sand. With this system there is no control on the injection rate.

There are numerous dump floods in operation in the Tri-State area. Some results have been favorable, and others adverse. Injection rates as high as 5000 bbl daily per input well have been reported.

In order to secure information on injection rates for dump floods, a metering device may be used to measure and control the volume of water. The injection medium is obtained by perforating the casing opposite a suitable water sand and the pay is flooded by the hydrostatic pressure of the fluid column in the well. The metering device is run on tubing with a hook-wall packer set below the perforations in the casing. Water passing through the meter rotates a vertical shaft turbine which operates a set of reduction gears. A cam periodically releases a trip hammer, which strikes a metallic block. The sound is transmitted to the surface and can be heard by ear or recorded by a surface instrument. By calibration of the meter, the number of hammer blows in a given period of time is converted to volume. Cost of the metering device and recorder, exclusive of the packer and tubing, approximates $1500.

Some installations have a surface injection system, which consists of a water source, pressure pump, and all the accessories common to a typical sand flood. An example of this type of installation is the Birk City Flood, in 18-P-27, Henderson and Daviess counties, Kentucky. There was evidence of results from an accidental flood in this pool, and the various operators agreed to a cooperative plan of flooding. Five input wells were placed in operation to serve approximately 380 acres in the flood area. Water was pumped from the Green River, metered and injected into the sand. Prior to the initiation of the planned flood, the pool had produced approximately 1,250,000 bbl of oil. Cumulative recovery to date is 1,780,000 bbl or 430,000 bbl of secondary oil. The

†Presented at the Kentucky Oil and Gas Association meeting, June 5, 1953, Lexington, Kentucky.

*Division Waterflood Engineer, Ashland Oil and Refining Company.

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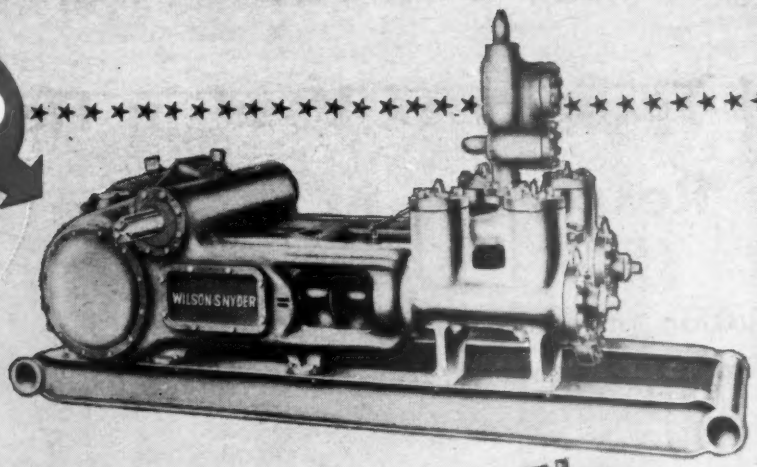

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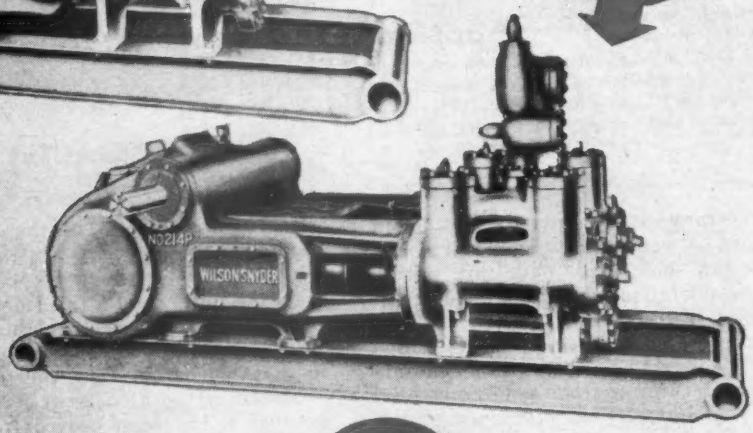

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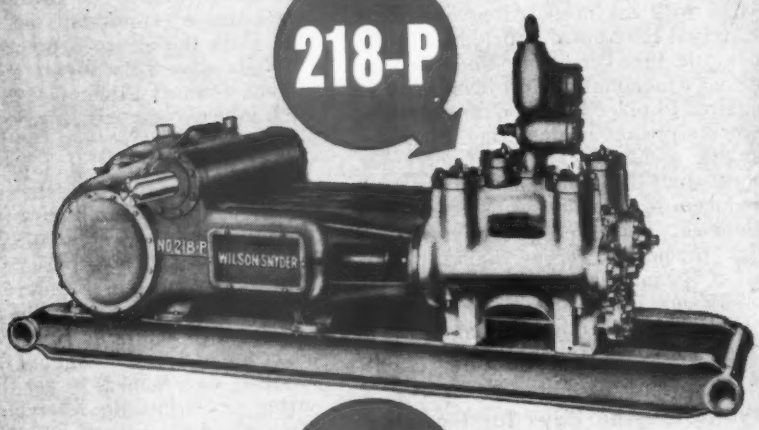

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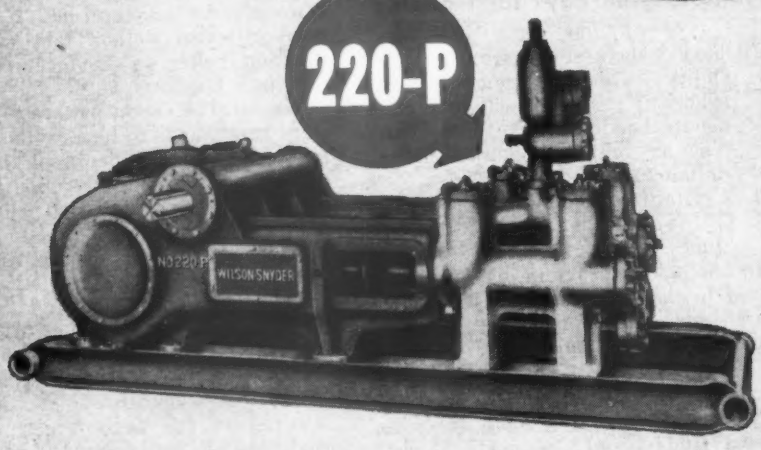

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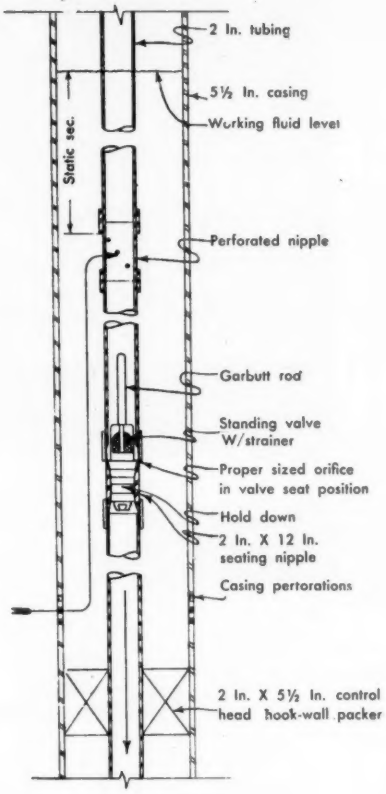

FIG. 1. Orifice control arrangement for subsurface injection.

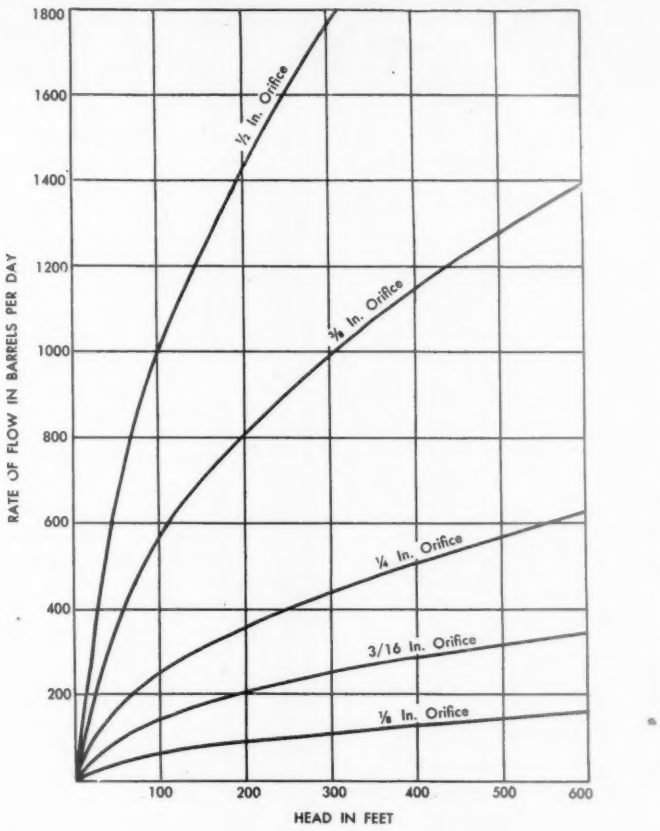

FIG. 2. Flow of water through sharp edged orifice.

flood oil recovered to date is 24 per cent of the primary recovery prior to secondary operations.

The surface injection system has the advantages of control on rates and pressures, but is also expensive.

A modification of the surface injection system is a well equipped with a cross over packer and a conventional pumping unit. By means of a system of packers, water is obtained from perforations in the casing opposite a water sand, raised to the surface, run through a meter loop, and injected in the oil pay in the same well. The pumping unit and the in-well pump serve a dual purpose in lifting the water and injecting the same into the oil zone. An improvement on the dump flood method and a relatively inexpensive installation is the controlled subsurface injection system. A mechanism consisting of an orifice mounted in a cage and hold-down, and housed in a seating nipple is run on tubing in conjunction with a control head hook-wall packer. Refer to Fig. 1.

The pumping equipment is removed from the proposed input and the oil producing zone is given a wash with 2 or 3 bbl of acid. A brush or bridge-plug is placed below the selected water sand and the pipe is perforated to allow entrance of brine into the casing. The well is then swabbed to remove drilling mud and particles of cuttings and cement behind the pipe.

The following data are recorded: The well is allowed to stand and reach equilibrium in order to determine the static fluid level in the hole. The well is then swabbed at a rate approximately equal to the desired daily injection volume. Notation is made of the drawdown and the working fluid level for the withdrawal and from this information, the orifice and seating nipple depth is calculated. A given size orifice will have a through-put volume dependent upon the differential head; or with any two known factors of the following three, namely: Daily rate, orifice size, and differential head, the third factor can be calculated. Refer to Fig. 2 and Table 1.

After the water data are secured, the bridge plug is knocked to bottom, and the packer and seating nipple are run on tubing and set at the desired depth. The packer is set below the perforations in the casing. The brine enters through the perforations into the annulus between the casing and tubing, and rises to a set of open tees, a gas cage or perforated nipple, thence down the tubing through the orifice and into the pay zone. The orifice disc is substituted for the ball and seat in the cage and hold-down. A short piece of rod is screwed in the top of the cage to permit retrieving with a rod socker.

The installation depends on gravity, or the hydrostatic head of the column of water. A well with a good primary history or of good injective capacity must be selected for conversion.

The installation has a good measure of flexibility. If a large injection volume is desired, the cage is pulled and a larger orifice inserted. For smaller rates, a smaller orifice is used.

Cost of conversion, excluding the value of the tubing, is aproximately $1800 per well.

Major items of expense:	
Cable tool rig—5 days @ $200	$1000
Perforating	450
Packer	275
Orifice control	60
Miscellaneous supplies	25
Total	$1810

Some reduction in cost could be made

TABLE 1. Calculated flow through orifices.

Orifice dia., inches	Head above orifice — feet: 100	150	175	200	250	300	350	400
	Volume — barrels per day							
1/8	65	78	84	91	102	110	119	128
5/16	144	174	188	203	228	248	268	287
1/4	255	310	335	360	405	440	475	510
3/8	575	705	760	815	910	995	1075	1150
1/2	1020	1240	1340	1440	1620	1775	1900	2040

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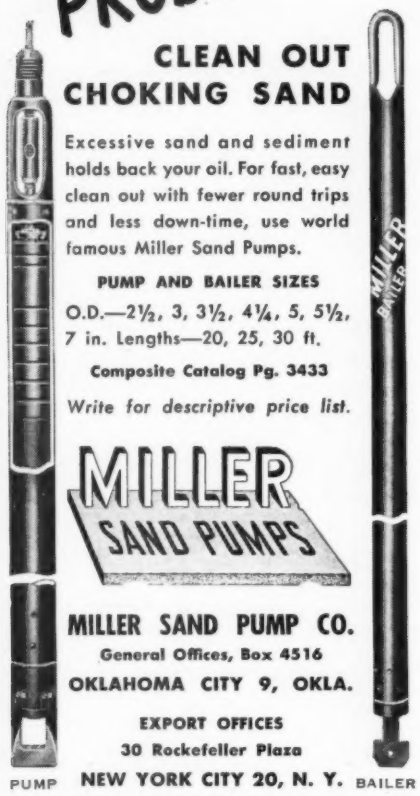

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by contracting a number of input wells in order to reduce the minimum rate on the rig. There are other expenses incident with operations which must be taken into consideration such as dozer bills, etc.

Operational Notes for Subsurface Injection

1. Select a well that had been a good producer. Attempts to reacidize a poor well that had previously been given full treatment have been unsuccessful.

2. Perforate the casing opposite the water sands where there is cement behind the pipe. Sloughing of mud and caving shales will plug-off perforations.

3. Have a small petcock on casing head to vent dissolved gas in brine. If this precaution is not taken, the system will be gas locked. The whistling from the vent is an indication to the pumper that the well is working. Check for trouble if there is no sound.

4. Use good clean tubing above orifice to reduce accumulation of pipe scale, paraffin, and B. S. on cage and orifice.

5. Make provisions for fuel if dependent upon gas.

6. Run float periodically. A rise in fluid level, approaching or equal to the static, indicates plugging of the orifice or pressuring-up of the formation. A serious drop in fluid level indicates plugging of perforations in the casing, a decrease in the productivity of the water sand, or a packer failure.

7. Anticipate erratic behavior. Occasionally production will have a tendency to "slug" with total fluid produced in excess of the capacity of pumping equipment. Daily production curve will have peaks and depressions in spite of constant operating practices.

8. Do not abandon a producer immediately offsetting an input, if the oil well has failed to respond and others more distant have increased in production. The water may be moving down structure, or following the path of least resistance. Reservoir fill-up, vertical permeability, and control of rates on producing well will eventually cause the reluctant producer to respond.

9. Watered-out producers occasionally can be brought back on oil production by rearranging inputs and exerting a drive from a different direction.

Conclusion

Only a few of the possible methods of introducing water into limestone reservoirs have been discussed. Economics are the controlling features which will ultimately decide the type of injection to use. Records to date, give recoveries for flooding of limestones ranging from 15 to 35 per cent of primary and in some isolated cases as high as 50 per cent. Effective natural water drives augmented by the injection of extraneous water in the early life of a pool are in a separate classification with considerably higher recoveries.

Knowledge of the reservoir, characteristics of the pay zone, and production history are of prime importance in evaluating the secondary potential of a limestone reservoir. * * *

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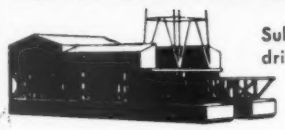

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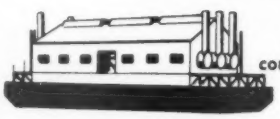

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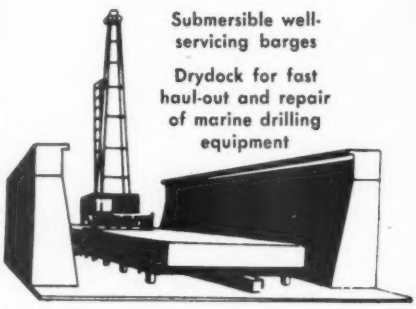

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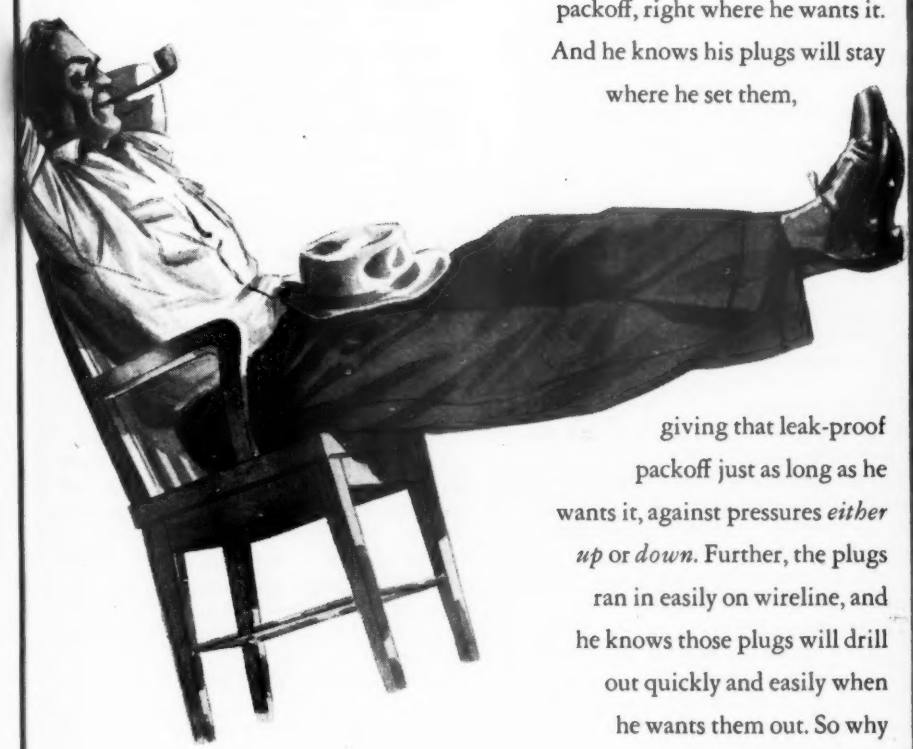

giving that leak-proof packoff just as long as he wants it, against pressures *either up* or *down*. Further, the plugs ran in easily on wireline, and he knows those plugs will drill out quickly and easily when he wants them out. So why shouldn't he be cheerful!

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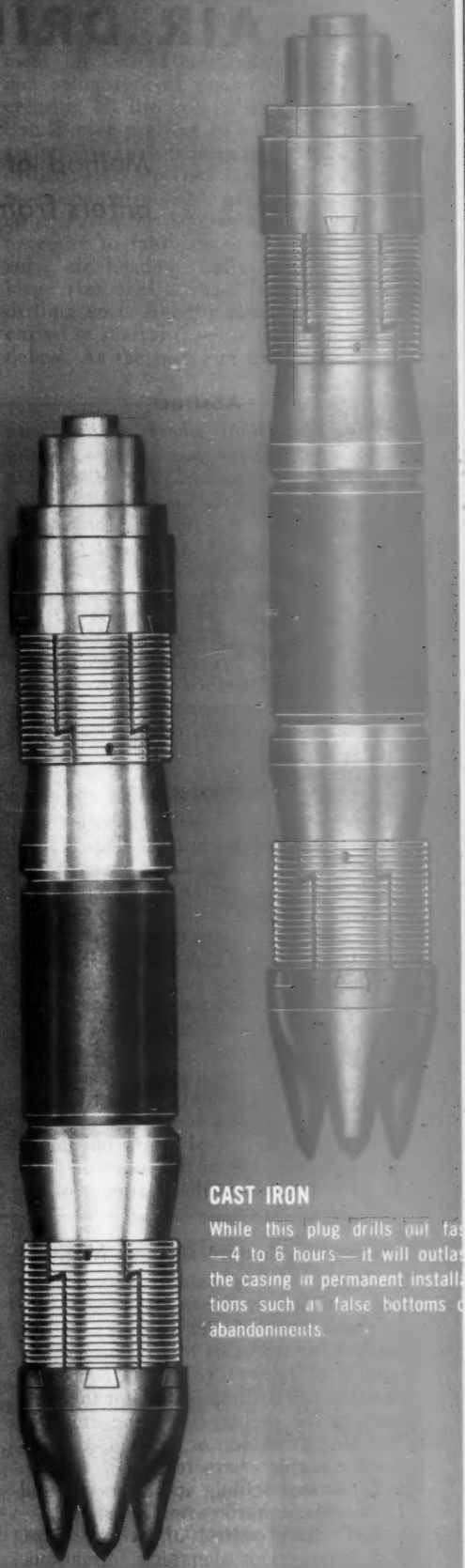

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AIR DRILLING IN CALIFORNIA†

Method of pneumatic drilling has been expanded and differs from rotary solely in character of circulating fluid

K. M. NICOLSON*

Abstract

The conditions where drilling with air for circulation may be economically feasible are discussed. Four California operators have used air for drilling surface holes where severe loss of circulation conditions and limited water supply exists and this experience is analyzed. The air requirement to lift cuttings is derived and a graphic solution for this requirement is presented. Equipment and operating procedures used in air drilling are described and some desirable future development to increase the scope of application of this method is suggested.

Introduction

SINCE the first oil well was drilled with rotary tools in the Spindle Top field of Texas in 1901, remarkably little change has been made in the basic method of rotary hydraulic drilling. It is the purpose of this paper to discuss a development that marks a departure from the standard rotary method and that recently has shown promise of success for drilling under certain conditions. The use of air or natural gas for circulating fluid with rotary equipment is not new, but the application of this method has recently been expanded. This method, which could be called rotary pneumatic drilling, differs from the rotary hydraulic system solely in the character of the circulating fluid.

Rotary Hydraulic Drilling Method

Of the approximately 5400 drilling rigs operating in the United States, 3700 or more than 68 per cent are rotary, while 1700 are cable tool rigs. The popularity of rotary drilling as compared to cable tool drilling is due, for the most part, to the reduction in time and cost resulting from one or more of the following major characteristics:[1]

1. Greater drilling speeds in soft and medium hard formations.
2. Primary control of well pressure.
3. Support for sloughing formations.
4. Means of directional drilling.

In addition to the above advantages, rotary drilling has several inherent disadvantages, the most important of which are:

1. Possibility of injuring the producing zone by drilling fluid and particle peneration.
2. Possibility of overlooking productive measures.
3. Possibility of contaminating cores and cutting samples.
4. Susceptibility to loss of circulation.

Rotary Pneumatic Drilling Method

The substitution of gas in place of liquid for the circulating medium has the effect of minimizing the four disadvantages listed above. Two advantages of rotary drilling are nullified as well, namely, control of well pressure and support for sloughing formations. The principal characteristics of the rotary pneumatic method as compared with conventional rotary drilling are:

1. Greater drilling speed and bit life.
2. Less susceptibility to loss of circulation.
3. Less possibility of injuring the producing zone by drilling fluid and particle penetration.
4. Less possibility of overlooking productive measures.
5. Less possibility of contaminating cores and cutting samples.
6. Less primary control of well pressure.
7. Less support for sloughing formations.

The principal limitations of present day air drilling technique are the inability to cope with water bearing strata or sloughing formations. For drilling with natural gas or drilling with air in gas bearing zones, a considerable fire hazard exists.

Application of Rotary Hydraulic Drilling Method

Admittedly, the scope of application of air or gas drilling as we now recognize it is based on very limited experience, and it is reasonable to anticipate that with time, additional techniques and equipment will be developed that will extend this application. At this time, however, drilling with liquid circulating fluid appears to offer advantages where one or more of the following conditions prevail:

1. Where high formation pressures are anticipated.
2. Where sloughing formations are encountered.
3. Where loss of circulation is not a problem.
4. Where producing formations are not susceptible to deleterious effects from drilling fluid and particle penetration.

Application of Rotary Pneumatic Drilling Method

Drilling with air or gas, however, appears to offer advantages where formations do not tend to slough nor contain appreciable amounts of water, and one or more of the following conditions exists:

1. Severe loss of circulation.
2. Producing formations are susceptible to injury from drilling fluid or particle penetration.
3. Drilling fluid is expensive or nonavailable.

Application of Air Drilling in California

The recent success with the rotary pneumatic drilling method in California has been made using air for the circulating fluid. Some California operators have experimented with natural gas for circulation in the past, and they reported that improved completions were affected.[2] This report, however, will deal principally with the more recent air drilling operations.

Comparatively few wells have been drilled with air to date. Four operators have used air circulation on a total of 14 wells in the South Mountain and Oat Mountain fields. On all of these wells, the major problem confronting the operator was severe loss of circulation in the surface hole. At South Mountain the surface formations consist of highly fractured shales and broken volcanic formations to depths of 1200 ft. Conventional rotary drilling has proven unattractive due to the excessive cost of combating loss of circulation, and the water supply available is insufficient for drilling with partial or no returns. Formerly the practice was to drill the surface hole with cable tools, but this was time consuming and difficulties were ex-

†Presented at the spring meeting of the Pacific Coast district, Division of Production, American Petroleum Institute, Statler Hotel, Los Angeles, California, June 2 and 3, 1953.

*Standard Oil Company of California, La Habra, California.

perienced with crooked holes. At the Oat Mountain area, west of Aliso Canyon field, the surface formations consist of dense, nodular, fractured shale with some sands and severe loss of circulation is characteristic principally above 1200 ft. Conventional rotary methods have been expensive in this area due to loss of circulation. Here also there is insufficient water available to drill without returns. In both of these areas air drilling proved capable of penetrating severe loss of circulation zones economically.

Evaluation of Air Drilling in California

In all of the 14 wells mentioned above, the rate of penetration while using air was higher than in comparable wells drilled with mud. The increase in drilling rate ranged from 40 to over 200 per cent greater than correlated intervals in adjacent wells drilled with mud. Table 1 shows the comparison of rates of penetration of several typical air drilled wells with rates realized on adjacent wells drilled with mud. This increased rate is experienced with either air or gas drilling and is usually attributed to the following conditions:

TABLE 1. Rate of penetration.

Well	Hole size in.	Depth drilled with air ft	Average rate of penetration ft per hr	Comparison with hydraulic drilling* % increase
A.....	12¼	0–834	42	135
B.....	12¼	0–963	41	131
C.....	12¼	0–1002	33	88
D.....	12¼	210–1058	24	119
E.....	15	22–1143	21	43
F.....	12¼	0–888	29	237
G.....	12¼	34–698	6	143

* Rate of penetration with air compared to rate with mud in adjacent wells.

TABLE 2. Bit footage.

Well	Hole size in.	Depth drilled with air ft	Bits used	Average bit footage ft per bit	Comparison with hydraulic drilling* % increase
A.....	12¼	0–834	2	417	36
B.....	12¼	0–963	2	487	59
C.....	12¼	0–1002	2	501	63
D.....	12¼	210–1058	4	212	70
E.....	15	22–1143	2	561	175
F.....	12¼	0–888	2	444	348
G.....	12¼	34–698	6	111	110

* Bit footage with air compared to footage with mud in adjacent wells.

TABLE 3. Air drilling cost comparison.

	Mud circulation	Air circulation
Rigup cost		
7500 ft rig in and out.....	6,000	6,000
Air equipment in and out.....	....	1,500
Total rigup costs.....	6,000	7,500
Drilling cost to 1000 ft		
Mud circulation 8 days		
Rig time.....	7,200	....
Drillpipe rental.....	120	....
Bit rental.....	2,040	....
Mud costs.....	1,200	....
Fuel costs.....	560	....
Air circulation 3½ days		
Rig time.....	....	3,150
Drill pipe rental.....	....	80
Bit-rental.....	....	1,150
Compressor rental.....	....	2,000
Kelly packer rental.....	....	200
Fuel costs.....	....	420
Total drilling costs.....	11,220	7,000
Total drilling costs.....	11,220	7,000
Saving with air.....	....	38%
Total rigup and drilling cost...	17,220	14,500
Saving with air circulation.....	....	2,720

1. Cleaner hole bottom due to extremely high velocities around the bit.
2. Absence of mud cake.
3. Very low viscosity of the gaseous drilling fluid. [3, 4]

Another important characteristic of air drilling observed on all wells was increased bit life. The improvement in bit life ranged from 36 to more than 300 per cent of that obtained in adjacent wells drilled with mud. Table 2 shows a comparison of average bit footage in the typical air drilled wells listed in Table 1, and bit footage in comparable wells drilled with mud. Bit life improvement is attributable to one or more of the following factors:

1. The cooling effect of expanding air.
2. Cooling capacity of large volumes and highly turbulent velocities of air.
3. The rapid removal of cuttings.

Net effect of eliminating the requirement for loss of circulation materials, increasing rate of penetration and increasing bit life is a substantial reduction in cost per foot of hole. Unfortunately the actual drilling costs at the air drilled wells are not indicative of the magnitude of possible saving. The principal reason for the discrepancy was the necessity to fabricate or rent compressors, air headers, kelly packers and large size drill strings. In addition to drilling costs standby charges were incurred in several cases in order to avoid delays. As the factor of drilling cost is

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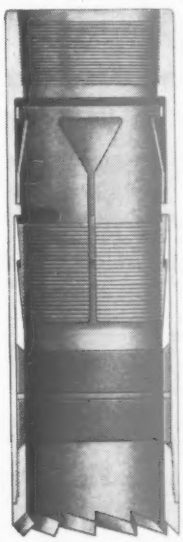

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probably the most important consideration in the evaluation of air drilling, an effort has been made to show a comparison between typical drilling costs using air and similar costs using mud based on actual drilling costs available. Cost figures have been adjusted to show a more equitable comparison by deleting certain abnormal charges that normally would not be incurred. These costs are shown in Table 3.

Mechanics of Air Drilling—Lifting Capacity of Air

Functions performed by the circulating air in air drilling are the removal of cuttings and the lubrication and cooling of the bit. Volume of air required to drill is governed by the cutting carrying capacity of the air. The size particle that can be lifted is dependent upon the shape of the particle, and is proportional to the density and square of the velocity of the rising air column.[5] Relationship between air velocity, air density, particle shape and particle size lifting capacity can be expressed as:

$$V_s = 2.67 \left(\frac{d\ \rho_p}{\rho_f} \right)^{1/2}$$

This formula which expresses the slip velocity of a sphere immersed in a fluid was derived from Newton's Law of Turbulent Resistance, $R_f = \frac{C_d A\ \rho_f V^2}{2}$ and the gravitational force acting on the sphere, $F = \frac{\pi\ g\ D^3\ (\rho_p - \rho_f)}{6}$. The quantities expressed in these formulae are shown under Nomenclature. Velocity of air required to float cuttings is equal to slip velocity of cuttings falling in an air stream. Under these conditions the fluid resistance force is equal to the gravitational force and the above formula is derived by equating these forces. The value of the fluid drag coefficient, C_d, has been determined experimentally for spherical particles and is available in the literature. Irregular shapes of drilling cuttings vary considerably from smooth spheres but in the highly turbulent conditions found in air drilling, this factor becomes less important and the variation is not so great as to impair the usefulness of this equation. Few field measurements of particle size taken to date tend to substantiate the above approximation and the suggested formula appears to be a satisfactory criteria for the design of air drilling equipment. It is also of interest to speculate on the probable effect of dust in the air stream. The cuttings of dust proportions will in effect increase the density of the air stream, and thereby increase its lifting capacity.

The lifting capacity formula developed above is shown graphically in Fig. 1, where the required air velocity may be determined for particular density existing in the air column that will lift a given particle size. Fig. 2 presents the graphical determination of the air volume required to provide the necessary velocity and density to carry cuttings in a given annular area. The air volume shown is given for standard conditions at sea level and the compressor capacity must be adjusted to provide an equivalent amount of air if temperature and pressure vary from these standard conditions. From the charts it will be seen that the air velocity and density in combination with the hole size and drill pipe size determine the air volume necessary to adequately clean the hole.

From the lifting capacity formula it will be seen that it is possible to lift fine cuttings with a reduced volume of air, however, in actual practice the regrinding necessary to reduce the cuttings to lifting size would slow the drilling rate excessively and increase bit and drill stem wear. It would be desirable to have sufficient air velocity to lift cuttings without regrinding, but practical considerations usually limit the lifting capacity to from ¼ to ½ in. particle size. For example, the air requirement to drill 1000 ft of 12¼-in. hole with 6⅝-in. drill pipe may be determined as follows:

1. On Fig. 1 enter chart at pressure of air in the annulus, say 16 psia (13.5 psi barometric pressure and 2.5 psi friction head).
2. Intersect temperature line assuming 160 F.
3. Read horizontal intersection on

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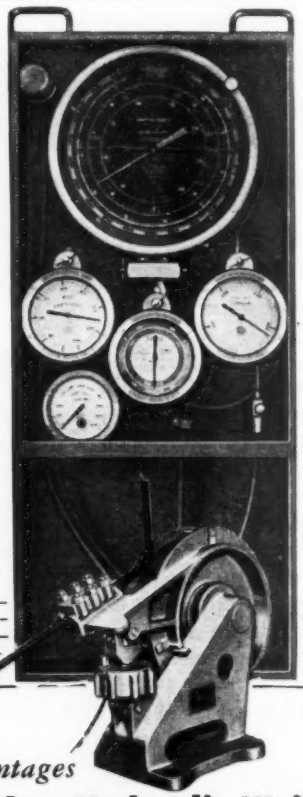

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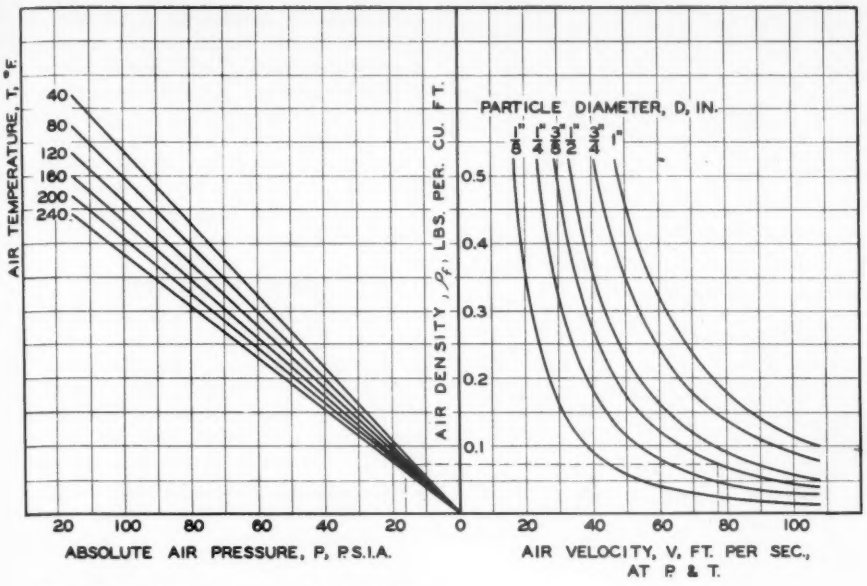

FIG. 1. Air lifting capacity determination.

density coordinate, 0.072 lb per cubic foot. This is the density of air at 16 psia and 160 F.

4. Continue horizontally on density reading and find intersection with desired particle size, say 3/8 in.

5. Read required air velocity 77 ft per sec. This is the required velocity of 0.072 pcf air which will float a 3/8-in. sphere.

6. To determine compressor capacity enter Fig. 2 at 77 fps velocity and intersect annulus area, 83 sq in.

7. Project horizontally to find volume at hole conditions of pressure and temperature and continue to intersect with density, 0.072 pcf.

8. Read required free air capacity, 2600 cu ft per minute, to provide 77 fps velocity and 0.072 pcf density in annulus.

Equipment Requirements—Drill Pipe

Large surface holes present a problem as considerable volume is required. however the requirement can be reduced by using large diameter drill pipe which will decrease the annular area and therefore the air requirement. If larger size drill pipe is not available it may be necessary to provide multi-stage compressors and raise the circulating pressure sufficiently to circulate the required volume. Drill pipe used for air drilling in California has included 5½ in., 6⅝ in., 7 in., and 9⅝ in. sizes. The volumes necessary to lift 3/8 in. cuttings in various hole sizes and with various drill pipe sizes are shown in Table 4. The reduction in volume possible with larger sizes of drill pipe is shown which is particularly significant in the larger hole sizes.

Compressor Plant

The compressor plant necessary to provide the lifting capacity as determined by hole size and pipe size is influenced by the pressure drop throughout the circulating system. Construction type portable compressors have been used on the air-drilled surface holes covered by this report as the required pressure was within the 100 to 110 psi compressor rating available with this equipment. The number of compressors used in parallel varied from 7 to 9 with combined capacities ranging from 3000 to 4500 cu ft per minute free air. It was found desirable to provide additional capacity to allow one compressor to be shut down for repairs without interrupting drilling operations. The 600 cu ft per minute machines appear to offer the best balance of capacity and portability for air drilling operations as they are the largest standard compressors mounted on 4 pneumatic tire wheels. Rental compressors have been utilized as the most economical source of equipment because the requirement was of short duration. Availability of sufficient rental compressor capacity for air drilling has presented a problem

TABLE 4. Calculated air volume required to lift 3/8-in. particles.

Hole diam. in.	Drill pipe size, in. 2⅞	3½	4½	5	5½	6⅝	8⅝	9⅝
6¼	758	660						
7⅞	1230	1130						
9⅝		1980	1780	1660	1500			
10⅝			2280	2160	2000	1700		
12¼			3200	3070	2950	2610	1860	
15½			5400	5300	5120	4830	4080	3620
17½				6910	6750	6450	5700	5250
20¾					9800	9500	8750	8320

Note: 1. Based on lifting capacity formula

$$v_s = 2.67\left(\frac{d\ \rho_p}{\rho_f}\right)^{1/2}$$

where:

d = 3/8 in. diameter sphere.
ρ_p = 162 lb per cu ft
ρ_f = 0.076 lb per cu at at 120 F and 16 psia
2. Air volume, cfm, adjusted to 68 F and 14 psia.

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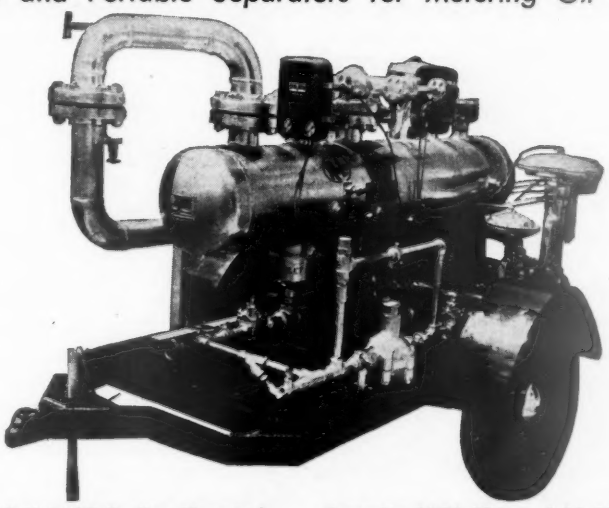

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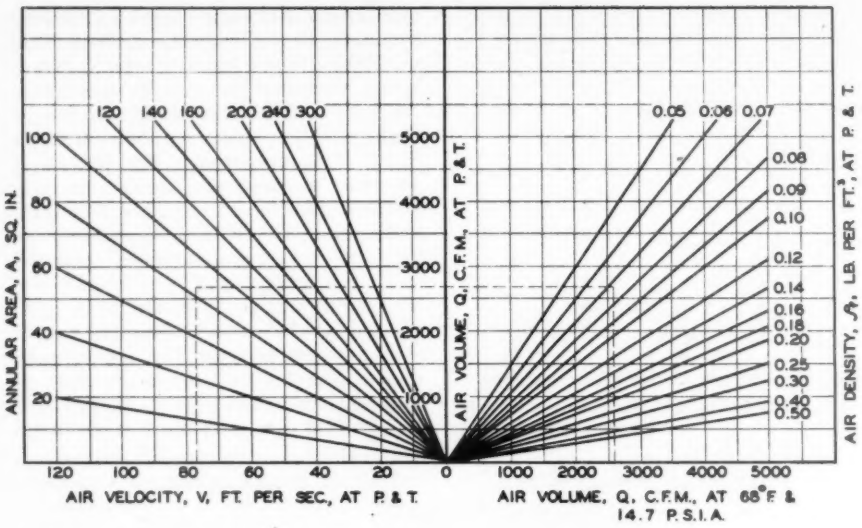

FIG. 2. Air volume determination.

which should improve as air drilling operations become more common.

Surface Air Piping

Size of the surface manifolding including stand pipe, rotary hose and swivel must be designed to accommodate the maximum volume of air to be circulated. The most economical pipe size is that which will not produce back pressure exceeding the capacity of the available compressors. It is advisable however to select pipe sizes which will keep pressures well below the maximum compressor rating if possible to allow for miscellaneous restrictions such as elbows, valves and totco plates.

Drill Stem

As previously mentioned, drill stem size is one of the basic considerations in determining air requirements. In general the advantages lie with large size drill pipe because annular area and air requirements will be reduced with corresponding reduction in pressure drop and compressor horsepower. These advantages tend to offset the additional time spent handling the larger sized drill pipe. Table 5 shows the magnitude of pressure drop in various typical sizes of circulating systems with 4000 cfm air volume. This table illustrates the importance of drill pipe size as it affects the volume of air. For example, the use of 4½ in. drill pipe in holes larger than 12¼ in. is inadvisable because the resulting high circulating pressures would necessitate two-stage compressors and involve a high horsepower requirement. The hole sizes, drill pipe sizes, air volumes and pressures used on the air drilled wells are shown in Table 6.

Bits

Bits used for air drilling to date have been conventional roller rock bits similar to those used in adjacent wells drilled with mud. Most of the bits, however, were bored out to provide a 2¼ in. circulation opening. A few bits were run with conventional mud nozzles, but no advantages were indicated. It is felt that the velocities are sufficiently high around the bit so that the additional air jet velocity is not accompanied by improved drilling rates, while the additional pressure drop encountered requires more compressor power. Several bits were run with special air vents to the bearings, similar to the treatment which has produced added bit life in gas drilled wells in West Texas, but there has been insufficient experience to evaluate effects of this feature to date.

Rotating Kelly Packers

Packing off the annulus at the drilling riser and diverting dust and cuttings into the exhaust line has been accomplished through the use of rotating kelly packers. The pressure on the packer is less than 2 psi, except where reverse circulation is employed. If reverse circulation is not contemplated a simple pipe wiper packer will serve, such as the low pressure packer illustrated in Fig. 3. The effect of reverse circulation will be discussed later and requires a conventional rotating kelly packer built to withstand several hundred psi pressure such as the high pressure packer shown in Fig. 3.

Air Exhaust Line

The exhaust air, dust and cuttings are conducted away from the rig through an exhaust line such as is shown in Fig. 4. The size of this line should be selected to provide a higher lifting capacity than that in the annulus so that cuttings will not be dropped in the line.

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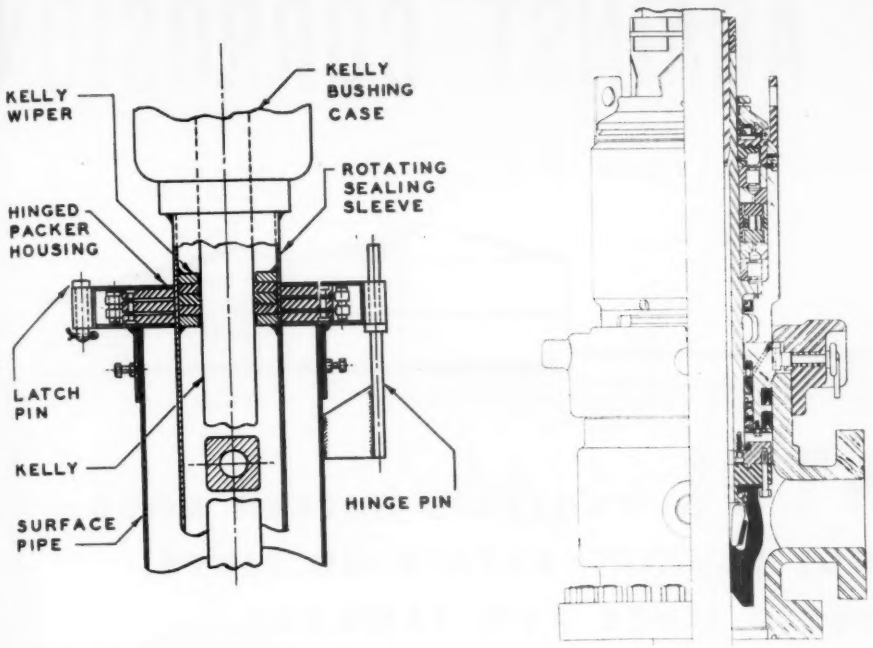

FIG. 3. LOW PRESSURE rotating kelly packer (left), and high pressure packer at right.

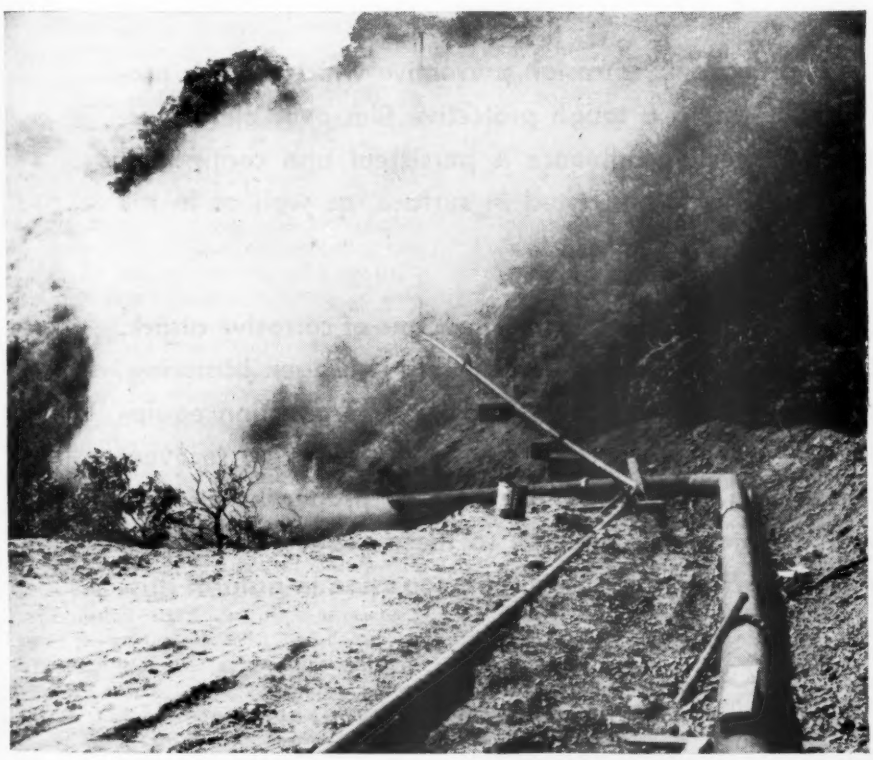

FIG. 4. View of air drilling rig.

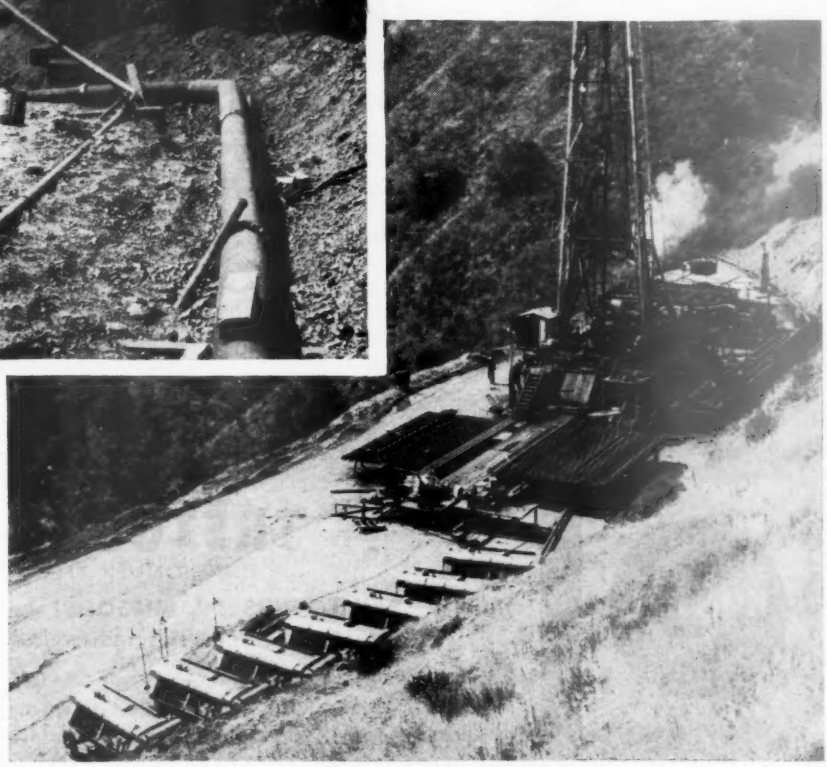

FIG. 5. General view of air drilling rig.

Cuttings must be disposed of without creating dusty conditions around the rig floor. In remote areas this is most economically accomplished by extending the exhaust line several hundred feet on the downwind side of the rig. In populous areas it may be necessary to install spray equipment or centrifugal dust separators for control.

Typical Air Drilling Rig

A typical air drilling rig is shown in Fig. 5 and the air facilities illustrated schematically in Fig. 6. The equipment layout with air circulation is more flexible than when mud is used as the air is not recirculated. The compressors may be located on any side of the rig, but it is advantageous to keep the air manifold line short and with a minimum number of bends. The several typical air systems tabulated in Table 5, show the amount of pressure drop in the various parts of the air system and this data serves to illustrate the desirability of having large size air systems.

Air Drilling Operating Procedures

Drilling with air is not unlike conventional operations in many respects. The rig compressors are run continuously and only shut down if operations are to be suspended for several hours. One valve on the standpipe is closed to shut in all compressors which unload automatically when the pressure reaches the set maximum operating pressure (usually 105-110 psi for construction type compressors). Drill pipe connections are made by stripping the kelly and drill pipe single through the kelly packer which should be lubricated with water occasionally to reduce friction. When a bit is to be pulled the kelly packer is unlatched from the drilling riser and set back with the kelly. These opera-

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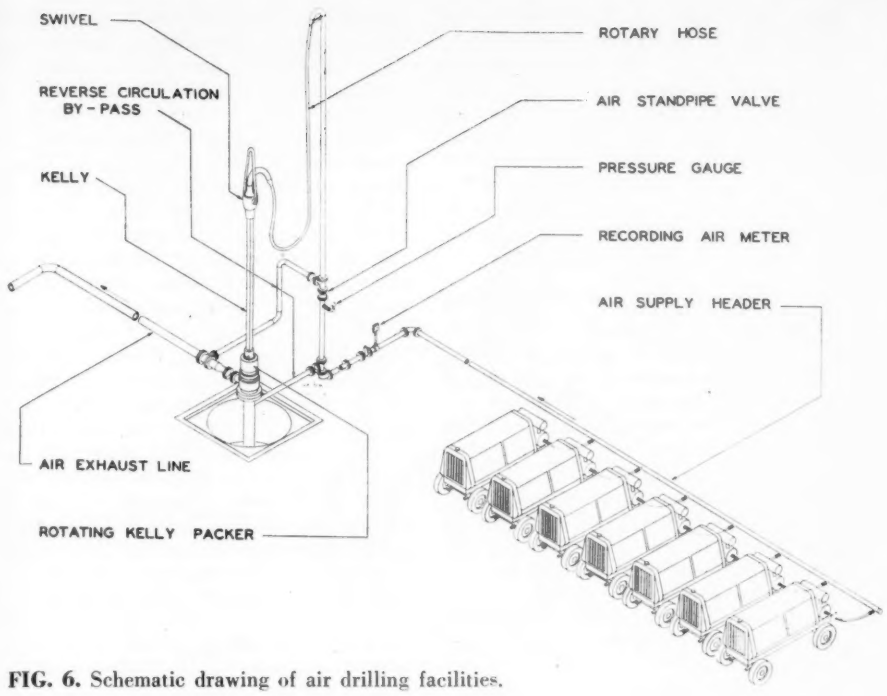


FIG. 6. Schematic drawing of air drilling facilities.

tions consume some additional time until the crews become familiar with the procedure and the operations become routine.

Drilling technique employed with air is slightly different from that used with conventional drilling. For example, the rotary speed usually is reduced to somewhat below normal to prevent excessive kelly packer wear. Also, bit weight may be increased without adverse effect because bit life is improved with air drilling and there is less tendency to drill crooked hole.[3]

Several drilling conditions are accurately and quickly indicated by the exhaust air. For example, moisture in the hole is marked by a sharp reduction of dust in the exhaust air while plugged bit or sloughing hole will cause air returns to stop. Within seconds after opening the standpipe valves, returns are seen from the exhaust line. Cuttings are rapidly carried from bottom hole to surface and formation breaks are readily determined from cutting samples. It must be remembered that although the air velocities are very high, only the smaller cuttings are rising near air velocity. The larger cuttings are rising more slowly or merely floating until reground to lifting capacity size. It is common to have a fill up of several feet of cuttings when air circulation is stopped. This material is composed of the larger cuttings which were traveling slowly up the hole or were suspended in the annulus. Air should be circulated for five or ten minutes before stopping circulation to make a connection or pull a bit to prevent excessive fill up.

The danger of sticking the pipe is apparently reduced under air drilling conditions. On a number of occasions, air circulation has been stopped with the bit on bottom, and an increase in pipe friction indicated the hole contained cuttings above the bit. In all cases it was possible to work the pipe free with air circulation. It was also possible to blow the bit through bridges or cuttings without rotation.

As pointed out above, the principal use of air drilling in California has been in loss of circulation areas. Air can be used to advantage under these conditions because the low pressure in the annulus (less than 3 psi) allows very little air to enter the formation and drilling may be continued unimpaired even in fractured formation. Loss of air circulation has, however, been experienced in one or two wells. The symptoms are a reduction in air returns and size of particles. A fill up of cuttings in the hole occurs whenever air circulation is stopped which may be due to the reduction in annular velocity above the loss of circulated zone. The reduced velocity air stream cannot carry the larger particles and they are held in suspension in the hole until reground to a smaller size. The partial loss of air circulation in the above cases did not stop drilling progress or appreciably slow drilling rates.

Two air drilling holes were stopped by sloughing formation. In both instances the holes were completed with mud. The indications of sloughing formations are that the hole cannot be cleaned and repeatedly fills in with cuttings. The resulting enlarged hole also reduces air velocity so that less material is carried out of the hole. It is doubtful that means will be devised for successfully drilling these formations with air. It is possible to drill in hole that has been enlarged due to the action of the drill stem if the formation is fairly competent and does not slough excessively. Additional compressor capacity is required for enlarged hole and this possible additional requirement should be evaluated when the compressor capacity is determined.

Another limitation of air drilling has been formation water. In fact air drilling progress was halted completely in several holes where water was encountered. Both hole and pipe were coated with a cake of cuttings which, if allowed to build up, formed a ball above the bit tending to stick the pipe. In a few cases where no free water was present in the formation, it was possible to resume drilling with air after removing the mud cake, otherwise the hole had to be completed with mud. It is pertinent to report the experience of geophysical shot hole drilling with air circulation where formation water has been encountered. On numerous occasions shot holes 4¾ in. in diameter have been completed to around 400 ft after water was encountered. The technique used was to stop circulation and dump water down the hole if the cuttings tended to ball. If a moderate amount of water was flowing, air drilling has been continued with a mixture of thin mud and air being exhausted from the hole until the hydrostatic head in the annulus exceeds the compressor pressure rating. These methods have been successful except where sticky formations were encountered. It is therefore possible that this apparent limitation may be overcome by improved technique and this possibility will be discussed later under reverse circulation.

Operations other than drilling are readily accomplished with air circulation. Casing is run and landed as in a mud-filled hole. Mud or water is pumped in ahead of the cement to prevent rapid dehydration before all the cement is in

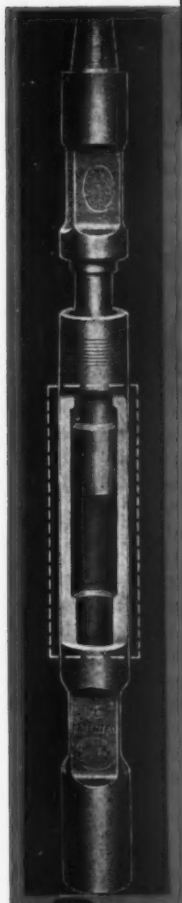
TABLE 5. Pressure losses typical air systems circulating 4000 cfm.

Item	Length, ft	Size, in	No. 1	No. 2	No. 3
Compressor hoses	10	1½	0.6		
		2		0.3	0.4
Air manifold	150	4½	3.5		
		6⅝		0.8	
		7			0.8
Standpipe	60	4½	1.8		
		5½		1.0	
		6⅝			0.6
Rotary hose	55	2½	13.8		
		3		10	
		3½			6.4
Swivel gooseneck etc.	6	2	12		
		2½		5.6	
		3			3.2
Kelly	60	2¾	11		
		3¼		8.4	
		3½			8.2
Drill pipe	800	4½	38 5		
		5½		22	
		6⅝			9.2
Drill collars	160	2¾	72		
		3½		30	
		4			16
Bit	1	2½	5	8	10
Annulus—12¼ hole	1000		1.25	1.25	1.25
Exhaust	300	10	1.25	1.25	1.25
Press. at compressors psi			160.7	88.6	57.3
Theoretical adiabatic hp			760	576	516

TABLE 6. Typical air circulation conditions.

Hole size in.	Drill pipe in.	Compressor capacity CFM	Annular* velocity FPS.	Calculated lifting capacity in.
12¼	6⅝	4045	113	0.77
12¼	6⅝	4500	126	0.96
15	7	4180	70	0.30
15	9⅝	4045	91	0.50

* Based on surface conditions of 13.5 psia and 80 F and bottom hole conditions of 16.0 psia and 160 F.



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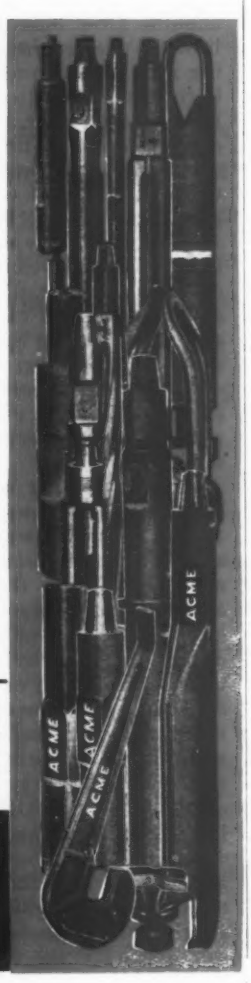

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place. No difference in effectiveness of cementing operations has been noted due to air drilling. One fishing job was successfully performed with air without difficulty. This work included washing over some cable tools and sidetracking and drilling past the fish. Whipstocks have been set and directional drilling operations conducted with air circulation. Rat holes have also been drilled with air successfully.

Future Development of Air Drilling

The future development of air drilling may broaden the application of this method by improvement in techniques and the development of special air equipment. The conditions which at this time appear to favor the use of air drilling have been enumerated as those where formations do not tend to slough nor contain appreciable amounts of water and where one or more of the following conditions exist:

1. Severe loss or circulation.
2. Producing formations are susceptible to injury from drilling fluid or particle penetration.
3. Drilling fluid is expensive or nonavailable.

It is entirely possible that air drilling may compete with conventional rotary drilling in some areas, due solely to the saving in bits and increased drilling speed. This will depend to some degree on the cost and availability of suitable air compressors in the future.

A technique that shows promise of broadening the application of air drilling is reverse circulation. This consists of circulating air down the annulus and returning cuttings and air up inside of the drill pipe. Under these conditions cutting lifting capacities are greatly increased with little increase in circulating pressure or the same lifting capacity may be obtained with a fraction of the air volume. Of equal importance, the air requirement is independent of the size of the hole which eliminates the disadvantage mentioned earlier concerning the volume of air required to drill large size holes. Reverse circulation is one of the most promising means of air drilling in wet formations proposed to date because of the high lifting capacity inside the drill pipe and the fact that cuttings will not contact the sides of the hole or outside surface of the drill pipe. Also, fluid may be added to the air stream to improve the fluidity of cuttings if they tend to become sticky. The most important prerequisite for reverse circulation is the ability of the open hole to withstand the full circulating pressure. Table 7 illustrates the air volume and compressor horsepower required to provide a constant lifting capacity of air with conventional and reverse circulation with various combinations of drill pipe and hole size. It is interesting to note the low compressor horsepower required with reverse circulation.

Equipment development that would improve operations and reduce costs with air drilling include kelly packers, air bits and large size drill pipe or drill casing. The kelly packers illustrated in Fig. 3 have proved adequate for their intended purpose but improvement is possible. A quicker operating latch and higher permissible rotary speeds are desirable. It would also be worth considering a means of aligning rotary table and drilling riser to relieve the rotating packer of excessive lateral movement.

More experience will be necessary before the optimum bit design for air drilling is understood. The cleaner hole may indicate shorter tooth bits to reduce the amount of regrinding before cuttings are of proper size for lifting. Larger circulation openings are definitely advantageous. Reverse circulations may require skirted bits to direct the air to the bottom before returning through the drill pipe and prevent bypassing air above the cutters.[6]

The savings in compressor horsepower with large size drill pipe should bring uncommonly large pipe into use. The heavy weight of drill pipe in these sizes may result in the demand for more

TABLE 7. Drilling conditions conventional vs. reverse circulation.

Hole size in.	Drill pipe size in.	Circulation direction	Compressor* capacity CFM	Compressor horsepower hp
12¼.....	4½	Conv.	3250	585
	4½	Rev.	400	20
	6⅝	Conv.	2600	220
	6⅝	Rev.	1000	50
15.....	6⅝	Conv.	4400	590
	6⅝	Rev.	1000	50
	9⅝	Conv.	3200	330
	9⅝	Rev.	3200	330

* Based on constant ⅛ in. lifting capacity.

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Conclusions

Air drilling has a limited scope of application with the present day development of drilling technique. It appears that conditions favorable for air circulation and expensive for mud circulation are required for the economic utilization of this drilling method. Conditions of severe loss of circulation and inadequate water supply have proven economical for air drilling in California. Limitations of air drilling indicated from experience in California are water bearing or sloughing formations. The scope of air drilling may be expanded by a reduction in cost of air equipment or improvement of technique to allow drilling where formation water is present.

Nomenclature

V_s = slip velocity of sphere, ft per sec

R_f = fluid resistance force, lb ft per sec^2

F_g = gravitational force, lb ft per sec^2

C_d = fluid drag coefficient of sphere when Reynolds number $N_R = 9 \times 10^3$ is 0.5

d = diameter of sphere, in.

D = diameter of sphere, ft

A = frontal area of sphere, $\frac{\pi D^2}{4}$, sq ft

ρ_p = density of particle, lb per cu ft

ρ_f = density of fluid, lb per cu ft

g = acceleration of gravity, 32.2 ft per sec^2

Acknowledgment

The author wishes to express his appreciation to the management of the Standard Oil Company of California for their permission to assemble the data necessary for the preparation of this paper. Acknowledgment is also due the Shell Oil Company, the Union Oil Company of California and the Ohio Oil Company for their cooperation and assistance which made this paper possible.

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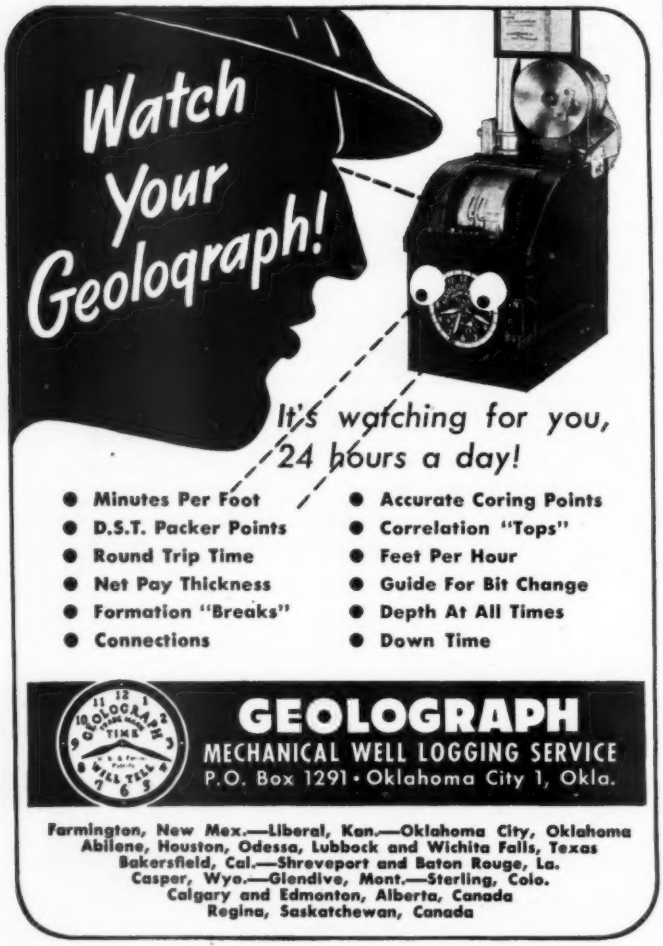
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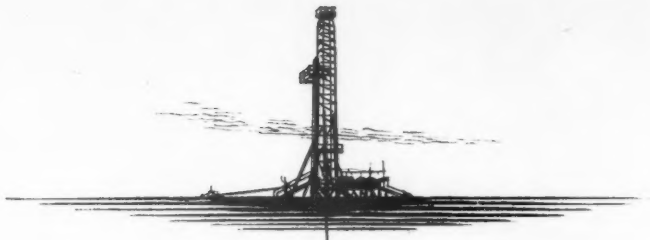

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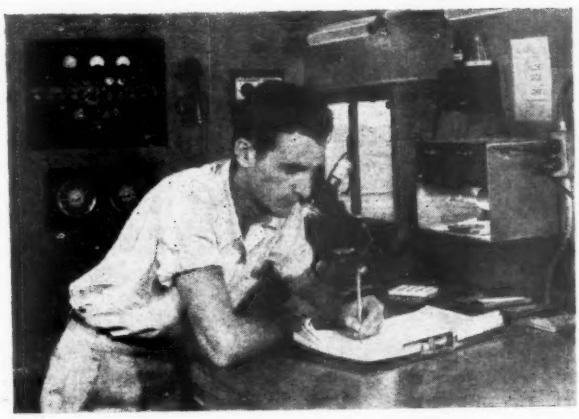

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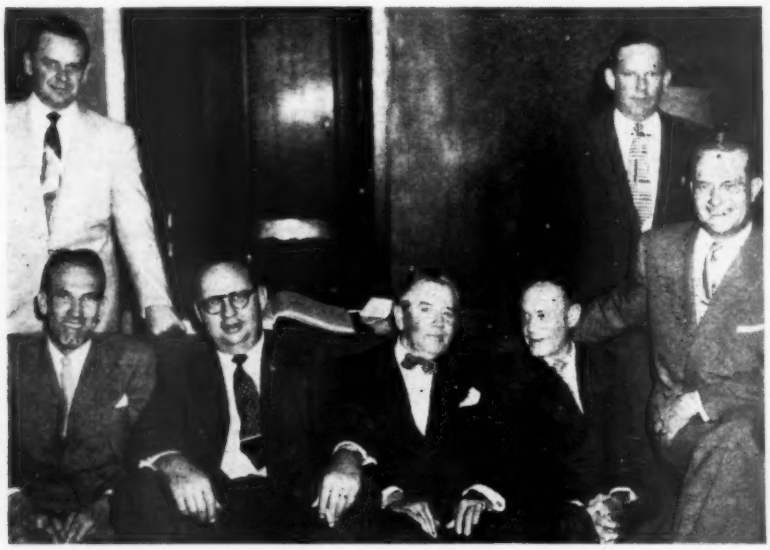
CORE LAB
WELL LOGGING SERVICE

HOUSTON NOMADS VISIT BAYSHORE. The Houston Chapter of Nomads held its June meeting at the bayshore home of Mr. and Mrs. Charles M. Smythe at La Porte, Texas. Forty Nomads and their ladies attended the barbecue and singfest, and participated in the program conducted by "Happy" Felton of Beaumont. Harry E. Estes is executive secretary of Houston Nomads.



ATTENDING A DALLAS-FORT WORTH Nomads meeting recently were: Back row, J. T. Tucker, Emsco Manufacturing, and R. J. Evans, Byron Jackson, Houston, Texas. Front row: Howard Walker, Magnolia Petroleum, D. S. Smith, Mid-Continent Supply; E. B. Hudson, Sun Oil; Herb Goodpasture, contractor, all of Dallas, and P. Z. Hilliard, Mid-Continent Supply, Fort Worth. In picture at right are: Glen Tableman, W-K-M Company, Dallas, Nomads, secretary of Dallas-Fort Worth Chapter; G. C. Waldrop, Oil States Rubber Company, Arlington, Texas, Nomads president; Joe Kelley, Reed Roller Bit Company, and Mark Gardner, Delta Gulf Drilling Company of Dallas. The June meeting was held in the Downtown Club of the Texas Bank Building in Dallas.

AIME Annual Meeting to Be Held in Dallas

Some 45 technical, economic, and general interest papers relating to the exploration, drilling, and producing phases of the oil and gas industry will be presented by outstanding engineers and scientists at the 1953 annual fall meeting of the Petroleum Branch, AIME, to be held in Dallas, Texas, October 19-21.

Some 1400 members are expected to attend the meeting which will be held in the Adolphus and Baker hotels. Committee heads are: Eugene R. Brownscombe, Atlantic Refining; R. J. Bradley, San Juan Oil, finance; Raul Bethancourt, Sun Oil, arrangements; Kenneth W. Robbins, Otis Pressure Control, registration; Ruford Modera, Republic Natural Gas, housing; John D. Wisenbaker, Core Laboratories, entertainment; Brad Mills, AAODC, publicity; William H. Justice, La Gloria, program.

On October 19, sessions will be held on field case histories, production equipment, and general interest topics. On October 20, sessions on drilling fluids, economics, and management, reservoir fluids, production operations, geological and reservoir engineering will be held.

On October 21, well completion, secondary recovery and natural gas topics will be presented. Each session will have from three to five papers.

John H. Murrell, DeGolyer and MacNaughton, Dallas, is general chairman.

Lion Oil Moves Offices

Lion Oil Company has announced removal to Wichita Falls, Texas, of its district land and geological office formerly situated at Amarillo. This office, which handles land and geological matters for the company in the Texas Panhandle and 18 counties of North Central Texas, is attached to the Southwestern Region which has headquarters at Midland.

The staff includes Charles B. Morgan, district geologist; Robert W. Thacker, district landman; Billy B. Clifton, Earl Harrison and Joseph A. Belvedere, geologists, and Roy P. Fischer, scout. Offices for the district will be in the Oil and Gas Building at Wichita Falls.

Los Angeles ASME Conclave Held

An estimated 2000 top engineers from all over the nation and many from abroad, gathered at the Statler Hotel in Los Angeles for the 4-day national conclave of the American Society of Mechanical Engineers recently.

At the President's luncheon, Frederick S. Blackall, Jr., Fellow ASME,

Frederick S. Blackall, Jr.

spoke on "The Forest-The Trees, A Reappraisal of Our Society." He was introduced by R. J. S. Pigott, Fellow ASME, and past president, ASME.

High spot of convention activities on the second day was the petroleum luncheon addressed by A. C. Rubel, vice president of exploration and production Union Oil Company of California. He spoke on "Petroleum's Place in Our Industrial Future."

In the evening Dr. L. A. DuBridge, president, California Institute of Technology, addressed the convention at a banquet on "Science, Industry, and the Government." Toastmaster for the event was J. Calvin Brown, Fellow ASME, prominent Los Angeles attorney and engineer and past national ASME president.

Service Companies Licensed For Fracturing Processes

Three more service companies have been granted licenses by Stanolind Oil and Gas Company to carry out fracturing processes for increasing well production. This brings to 10 the total number of service organizations licensed to use the Stanolind-patented processes.

E. F. Bullard, president of Stanolind, said the newly-licensed firms are M and K Oil Well Cementing, Inc., Seminole, Oklahoma; Chemical Process Company, Breckinridge, Texas, and Petroleum Service, Inc., Abilene, Texas.

Other companies previously granted licenses are Halliburton Oil Well Cementing Company, Duncan, Oklahoma; Dowell, Inc., Tulsa; The Western Company, Midland, Texas; Cardinal Chemical, Inc., Midland and Odessa, Texas; Producers Chemical Service, Borger, Texas; Acid Engineers, Inc., Lakin, Kansas; and Texas Acidizers, Inc., Seguin, Texas.

Bullard said the new license agreements further broaden the availability of the processes.

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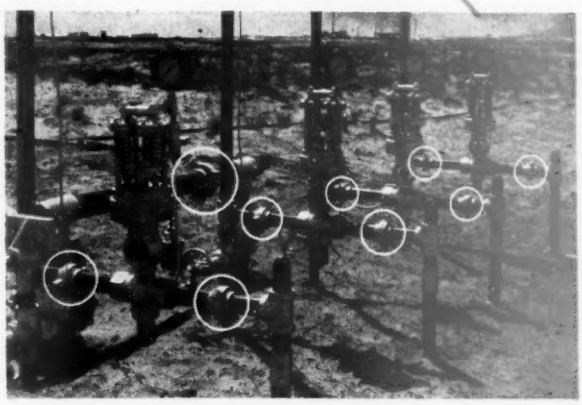
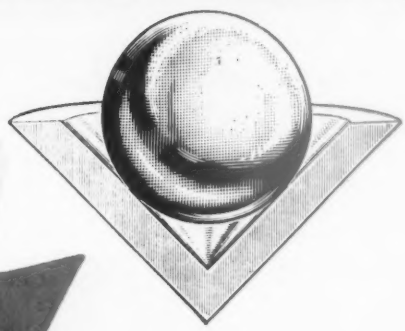
• Fig. 400 WECO Unions on a high pressure manifold.





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This quality in WECO Unions is the result of precision machining of the Ball and Cone Seat, wherein the spherical surface on the male sub seats on the conical surface of the female sub. The true line of contact between these two metal surfaces produces a seal that holds against high pressures, shock, surge and vibration . . . that is practically impervious to damage.

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Manufacturers and Distributors of Oilfield, Refining, Marine and Industrial Equipment

What's Doing in Drilling

NEW MEXICO

★ Additional Devonian production is assured by the recent completion of the Stanolind Oil and Gas Company's No. 6 Wingerd in the Gladiola field of Lea County. The well was drilled to a total depth of 12,035 ft and plugged back to 11,984. Completed in the pay which was topped at 11,830, the well was tested for 334 bbl daily through a 9/64-in. choke.

★ Republic Natural Gas Company and Seaboard Oil Company, both of Dallas, have completed the second well in the Siluro-Devonian White Ranch field of East Chauvez County. The well, White Ranch Unit No. 2, is a south offset to the discovery. Completed through perforations from 8728 to 8742 ft, production was 982 bbl in nine hours for a reported potential of 2620 bbl per day, after treatment with 750 gal of mud acid. Gas-oil ratio was reported at 459 to 1.

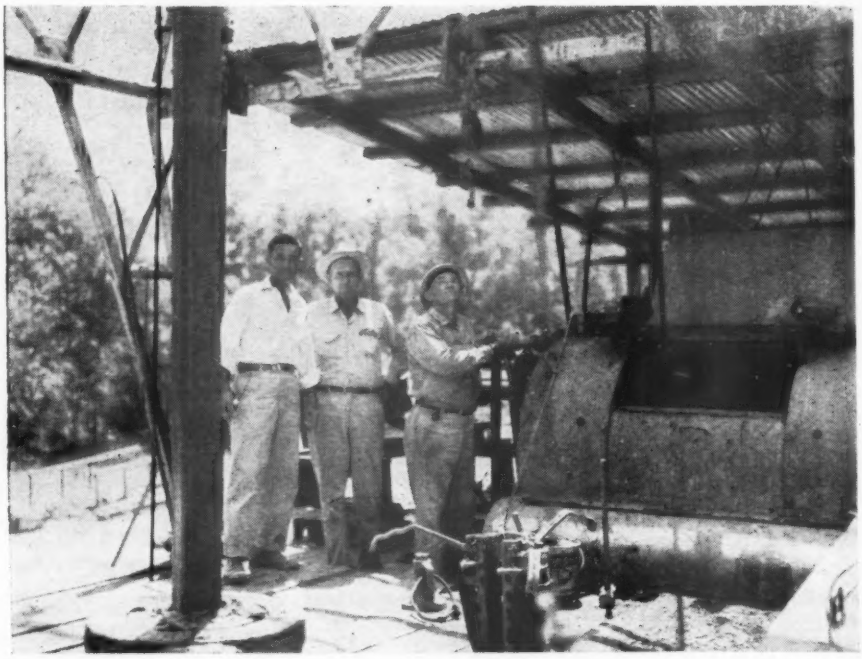
KUWAIT — SAUDI, ARBIA

★ American Independent Oil Company's second well on the Wafra structure in the Kuwait-Saudi Arabia Neutral Zone encountered oil sand at a depth of 3620 ft. This well is approximately 2¼ miles from the discovery well completed in March, and was drilled to test the northwest flank of the structure.

Preliminary tests indicated that the well will be a small producer and should be completed in the near future. Drilling in the Burgan sand zone was continuing and plans for the third test well of the structure on the completion of this well have been made.

NORTH DAKOTA

★ The Tioga field was extended almost two miles north by the recent completion of the Warren Petroleum Company's No. 1 Carl Anderson in Burke County. With 5½-in. casing set at 8220 ft, the gage was for 148 bbl per day through 7/32-in. choke. In the same area, Amerada came in for two completions, its No. 2 Blestrud flowing 408 bbl of oil in 17 hours and its No. 2 Borstad flowing 586 bbl per day.



DELTA DRILLING RIG. Bert Gauntt, tool pusher; Henry Barnett, mechanic, Noah Hart, driller. Scene is Delta Drilling's Rig 22 on location for B. G. Byers on the A. B. Moreland lease in the Carthage, Texas, area.

OKLAHOMA

★ Cities Service has completed its No. 1 Alcorn B in the multizone Purdy area of Garvin County with the well testing 233 bbl in 3½ hours through a ½-in. choke while flowing from both zones. Casing was perforated in the Hart sand from 8468 to 8515 and in the Springer sand from 9096 to 9174. Total depth of the well was 9250.

★ Shell Oil Company has completed the No. 1 Hocker-Woody in the Elk City field of Beckham County, well testing 292 bbl of 63.6 gravity condensate and 2,070,000 cu ft of gas flowing from perforations 9856 to 9990. The gas oil ratio was calculated at 7096 to 1. At the present allowable schedule, the well will be produced at approximately 42 bbl per day.

★ A good Oswego lime well, the No. 1 Curry, was brought in by Sun in Lincoln County. Drilled to a total depth of 3428 ft, lime was topped at 3337. Casing was set through and perforated from 3346 to 3358. After treatment with 2000 gal of acid, well flowed 415 bbl of 50 gravity oil in 5 hours through a ¾-in. choke. Reported gas oil ratio of 653 to 1.

★ Shell et al No. 3 Wingfield Beckham County, Elk City field, has been completed for a flow of 539 bbl per day of 65.2 gravity condensate. Flow was through a 22/64-in. choke with a gas oil ratio of 3978 to 1. Completion is from cased hole, casing having been perforated 9901 to 9935. Plugged back depth is 10,175.

★ Gulf Oil Corporation revealed a good test in the Skinner sand in the East Payson pool with an open hole test from 4120 to 4152 ft yielding 29 bbl per day natural. After fracturing well produced 299 bbl of load oil and 214 bbl of new oil in 15½ hours. As testing continued the well was producing at a rate of 27 bbl per hour.

★ The Stroud field received another Prue sand producer with completion of Sterling Oil Company's No. 1 Brooks. After treatment, the zone from 2900 to 2956 ft flowed from 30 to 35 bbl per hour through a ½-in. choke.

★ Sinclair Oil and Gas Company No. 1 Nettie Anderson in the Doyle pool in Stephens County flowed 235 bbl of new oil in 7 hours after treatment. Drilled to a total depth of 8581 ft, seven inch casing was swung at 7420 ft and perforated in the Upper Aldrich sand from 7214 to 7242 ft. Hydraulic fracturing then resulted in the above oil test along with 522,000 cu ft of gas per day.

Rotary Rigs Operating in Oil Fields of United States and Canada*

	June 8	June 15	June 22	June 29	July 6	July 13
Pacific Coast	170	175	173	171	170	171
Oklahoma	340	338	326	337	342	335
Kansas	170	174	166	159	176	162
Rocky Mountain	254	254	263	264	269	272
Canada	190	191	195	183	156	155
Ark-La-Tex	130	141	150	142	159	152
West Texas & New Mexico	474	468	476	479	488	495
Gulf Coast	596	601	600	601	592	552
Illinois	141	139	151	148	148	141
North Texas	346	341	345	341	351	335
Total	2811	2822	2845	2825	2851	2770

*As reported to American Association of Oilwell Drilling Contractors by Hughes Tool Company.

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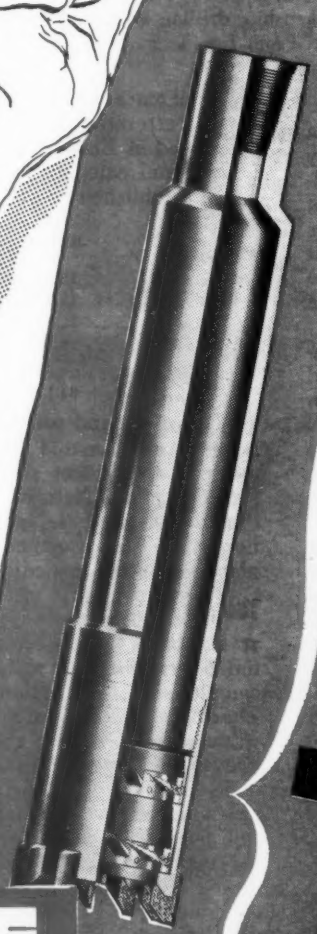
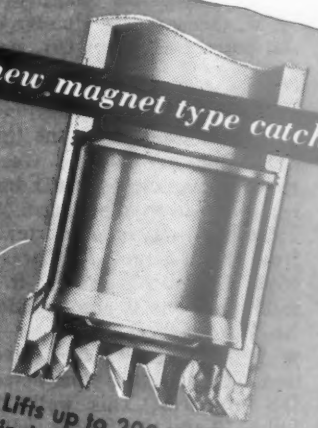


new magnet type catcher



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- Speeds up drilling operations
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- Available in sizes to match your hole program
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LAKE CHARLES and MINDEN, LOUISIANA

HARRY L. EDWARDS DRILLING COMPANY crew on rig No. 4 for Pan American Production Company in the South Gillock field was photographed at the rig recently. Edwards' crews have been operating for Pan American in this field since 1946, drilling the majority of the company's more than 90 wells there. Back row, are J. C. Dabney; M. W. Owens; J. D. Hulsey; O. D. Blankenship, drilling superintendent; Buddy Yates, tool pusher; and Jerry Orr, vice president. Front row, L. F. Crowder and Dee Lewellen.

CANADA

★ The completion of the third well in the Stanolind Oil and Gas Company Pigeon Lake field near Edmonton, Alberta, has been announced. Well flowed 735 bbl per day on a quarter inch choke from the D-3 reef. Reef was topped at 6602. Total depth is 7043 ft. Two more wells, each one 40-acre location from the No. 3, have been staked.

★ In the same area, Texaco Exploration Company has completed its 52nd D-3 producer. This well, the Pigeon Lake 13-36, had about 543 ft of oil saturated reef above the water contact. Situated near the center of the field, the East offset penetrated 570 ft of saturation and the West offset had 471 ft.

★ Socony-Vacuum et al announce the completion of their fourth Mississippian well in the southeast corner of Saskatchewan. Production data were not available but drill stem test in the interval 3520 to 3546 ft recovered free oil and heavily oil cut and gas cut mud. The tests compared very favorably with those made in the same formation in the Midvale area where completions made over 400 bbl per day after acid.

★ Canadian Gulf et al have completed the Stanwell-Peterson No. 16 at Erskine, Alberta. Announced producing depth was 5371 ft. Well was potentialed at 792 bbl of oil per day.

★ Bishop Oil Company announced that Decalta-Bishop Joseph Lake Well No. 1 in Alberta Province, Canada, has been completed with initial production of 326 bbl of 37 gravity oil per day on a three-day pumping test. Total depth is 3351 ft. Situated on a 160-acre Crown Reserve lease on the southern end of the Joseph Lake Oilfield, the well is about 20 miles southeast of Edmonton. Current field allowable is 50 bbl per well daily.

★ New British Dominion has completed the first phase of its gas development in the Etzikom area at Pakowki Lake, Alberta. Perforating and testing has been completed at Etzikom Nos. 1, 3, 4, and 5 wells and calculated open flows have been established with the following results:

Well No.	Maximum Daily Potential (Measured)
No. 1	12.0 million cu ft daily
No. 3	15.5 million cu ft daily
No. 4	25.5 million cu ft daily
No. 5	11.1 million cu ft daily
Total for 4 wells	64.1 million cu ft daily

The proved and probable recoverable reserves, as estimated by company engineers in the recent submission to the Petroleum and Natural Gas Conservation Board gas hearings, total 122 billion cubic feet. Further exploration is planned for the immediate future.

TEXAS

★ Kaufman County received a substantial reserve increase with the successful completion of the Humphrey No. 10 Tharp in the Ham Gossett area. The well was completed in what appears to be the twelfth pay section for the field. On drillstem test in the interval 3857-3860 gas surfaced in seven minutes and the well flowed oil in fifty-one minutes. During the hour and a half test the well flowed at the rate of twenty-five barrels an hour. Stem recovery was 2520 ft of oil. Casing has been set at the top of the pay section and the well finaled as an open hole completion.

★ Texas Gulf Producing Company has completed the third well in the Headlee field of Ector County. Producing from open hole in the Ellenberger from 13,325 to 13,393 ft, the yield was 508 bbl of 51 gravity oil in 12 hours through a ¼-in. choke. The Headlee No. 3 is a southeast offset to the discovery well in the field. Texas Gulf now has four rigs working in the area.

CALIFORNIA

★ Drilling and Exploration et al have completed their Stern Community No. 1 in Orange County as a successful extension of the Richfield field and as a new sand discovery. Producing through casing perforations from 4650 to 4985 ft, the well potentialed for 261 bbl of 19.7 gravity oil daily by pump. The Kraemer zone, encountered from 4168 to 4550 ft, is productive in the nearby Richfield-Atwood area. The new zone occurred from 4645 to the total depth of 4985, the 340 ft section being about 90 per cent effective oil sand.

★ The Reserve Oil and Gas Company Pauley No. 77-33 has been placed on production in the Tejon field of Kern County, California. Flowing from a depth of 4922 ft after having been plugged back and redrilled from 3622 ft, it tested for a potential of 209 bbl per day of 32 gravity oil. Flowing tubing pressure during the test was 575 lb. Reported casing pressure of 1025 lb reflects ability of the Valv zone in which completion was made.

★ Tide Water Associated Oil Company, Western Division, announced successful completion of its V.L. and W. Well No. 96, Ventura Avenue field, California, flowing at the rate of 569 bbl of oil per day, gravity 32.7, from a total depth of 10,079 ft. The new well establishes a daily gas potential of 600,000 cu ft.

MISSISSIPPI

★ Flowing at the rate of 107 bbl per day through a 10/64-in. choke, Gulf Refining's No. 31 Crosby Lumber and Manufacturing Company has brought new Wilcox production to southwestern Mississippi. The 33 gravity crude is being produced through casing perforations from 7092 to 7094 with a tubing pressure of 350 lb. The Nomenclature Committee of the Mississippi Geological Society has selected Saukum field as the designated name for the area.

★ In Monroe County, Union Producing Company has completed its No. 1 Ott Unit in the Sanders sand for an open flow potential of 33,000,000 cu ft per day. Production is from open hole from 5512 to 5554. Gas-condensate rate was not reported and the well is now shut in waiting for gas outlet.

★ Gulf Refining has also announced the completion of its Chapman-Smith No. 1 in the Hiwannee pool. This Eutaw sand completion pumped 95 bbl a day of 20 gravity oil. Production is through casing perforations 4313 to 4317 ft.

LOUISIANA

★ The Texas Company has announced the completion of its No. 2 State-Mallard Bay, as a flowing oil well. The 5½-in. casing, which is set and cemented at the total depth of 9205, was perforated in the interval 6092-6110. Tested on a one eighth inch positive choke, the well produced at the rate of 169 bbl of oil per day with a flowing tubing pressure of 975 lb. The gravity was recorded as 32.7 deg API. Completion marks discovery of a new pay section in the Grand Lake field of Cameron Parish.

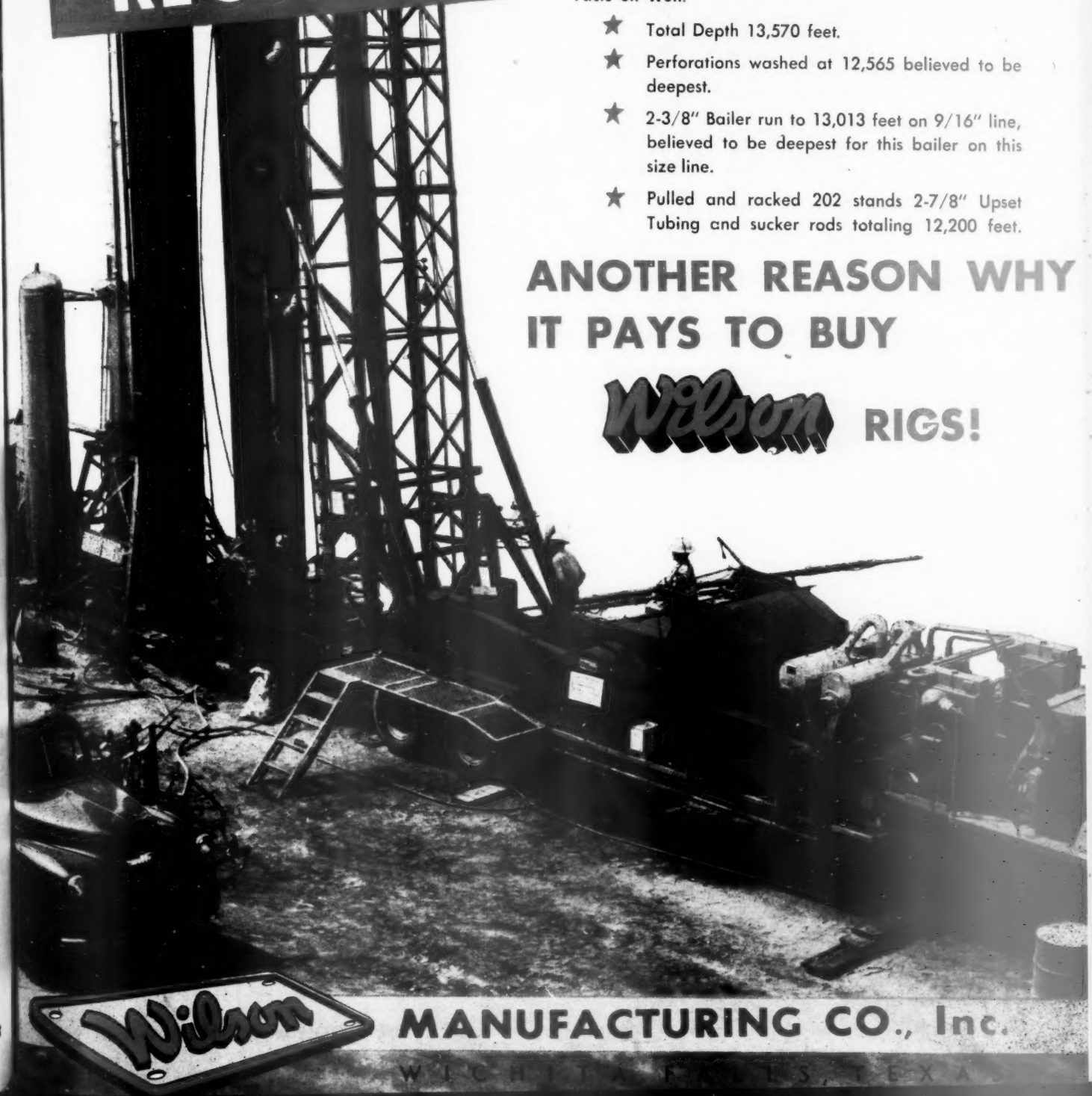
Wilson SETS A WELL SERVICING RECORD...

The photo below shows actual work in progress on what is believed to be the deepest well servicing job ever accomplished with a portable winch and mast. This well was in the Ventura Avenue Field and was done by the Harbor Production Company, Wilmington, California, *using a Wilson Mogul Torcair Winch* powered by GMC Twin Engine and Torque Converter and with a *Wilson Mogul Type Mast* of 260,000 rated capacity.

Facts on Well:

- ★ Total Depth 13,570 feet.
- ★ Perforations washed at 12,565 believed to be deepest.
- ★ 2-3/8" Bailer run to 13,013 feet on 9/16" line, believed to be deepest for this bailer on this size line.
- ★ Pulled and racked 202 stands 2-7/8" Upset Tubing and sucker rods totaling 12,200 feet.

ANOTHER REASON WHY IT PAYS TO BUY Wilson RIGS!



Wilson MANUFACTURING CO., Inc.

WICHITA FALLS, TEXAS

Exploration Activities

CANADA

★ Rainbow Oil Ltd. has added a natural gas reserve to its oil reserves through the discovery of a new field on its Fork Lake reservation in Alberta, Canada. Drillstem tests indicate that the first well has a gas production capacity of 1,240,000 cu ft per day, from the Cretaceous formation at a depth of 1600 ft. Fork Lake is about 100 miles northeast of Edmonton and 60 miles northeast of the Redwater field, one of the richest oil fields found in Alberta.

★ Tide Water Associated Oil Company reports a heavy oil discovery in Saskatchewan. The No. 5-21 Dollard Crown tested the Jurrasic formation from 4559-69 ft, recovering 1750 ft of gas cut oil of about 18 gravity. On test after setting casing the well was reported making about 240 bbl of oil per day.

★ The Texas Exploration Company has found substantial shows in the cretaceous in the No. A-1 Ponoka, Alberta. From 5105-37 a drillstem test indicated 2,800,000 cu ft of gas daily. From 5233-53 ft test recovered 90 ft of oil cut mud, and from 5250-56 recovery was 100 ft of gas cut mud, 2000 ft of gassy oil, and 900 ft of salty water. Operators are drilling ahead.

COLORADO

★ The California Company has given the Denver-Julesberg Basin in northeast Colorado the second Lyon sand pool of the year with the successful drillstem test of the sand in No. 1 Baiamonte. This old well was cleaned out and drilled deeper to the Permian age Lyon member. Drill test recovery was 6500 ft of oil.

TEXAS

★ Crown Central reports completion of its No. 1 R. E. Broz, a Tom Green County Ellenburger discovery, southeast of San Angelo. The well tested 149 bbl per day of 38.1 gravity oil on 7/32-in. choke. Casing was set through and perforated 5420-5455 ft. Test was made after treating lime with 500 gal of acid.

★ The Texas Company No. 1 Parker has been completed in two producing zones as the discovery well of a new field in West Texas. From perforations, 8596-8608 ft and 8623-36 ft, in the Wolfcamp lime, the well flowed 150 bbl of oil in 3 hours and 15 min through a 25/64-in. choke. Tubing pressure was 330 lb and the gas-oil ratio 597 to 1. Drilled to a total depth of 8823 ft, the well was plugged back to 8770 ft. The new discovery is near the town of Andrews, and is about a mile and a half north of the nearest production in the Parker field, which produces from approximately 4650 ft.

★ Ashland Oil and Refining, et al, has tested the No. 1 Wallace in Sutton County. Producing from 4997-5026 ft in the Strawn reef the well gassed in three minutes and flowed oil in 16 minutes, through drillstem. Core analysis indicates approximately 500 ft of saturated section.

★ Completion of a gas well in Jackson County is announced by The Texas Company. The No. 1 F. L. Franek was gaged for an open flow potential of about 6,500,000 cu ft, producing from casing perforations between 3844-48 ft. Tubing pressure was reported at 1375 lb. Drilled to a total depth of 5504 ft, the casing was set at 3908 and perforated for completion.

★ D. H. Byrd, et al, in Milam County have tested the Pettit zone from 7682-7700 for an estimated 10,000,000 cu ft of very wet gas a day and the Upper Glen Rose from 6245-6313 for an estimated 6,000,000 ft of gas a day, in their No. 1 Lucinda Greene. Well is located about 3½ miles west of Gause.

NEW MEXICO

★ Richardson and Bass in their No. 1 George H. Cobb-Federal, in Lee County, have opened a new Delaware sand pool in the deep wildcat. Drilled to the granite at 16,459 ft, the well was plugged back and on a 10-hour test through perforations from 7003-7035 ft it flowed 6 bbl of 38.2 gravity oil per hour.

★ Stanolind Oil and Gas Company, et al, No. 1 State AB, Eddy County wildcat is drilling ahead after test for an estimated 50,000,000 cu ft of sweet gas per day from the Pennsylvanian section from 10,135-10,241 ft. Objective is Ellenburger, expected at about 13,000 ft.

KENTUCKY

★ The R. E. Hupp, at No. 1 Hoover, McLean County, encountered 11 ft of Cypress zone porosity topping the zone at 2002 ft. Casing was set on top of zone and well swabbed in. No details of completion test have been released.

ITALY

★ Following geological, gravity, and seismic surveys in Sicily, D'Arcy Exploration Company, Anglo-Iranian's prospecting subsidiary, is to drill a test well in the Vittoria concession area. Arrangements are now being made for drilling by contractors to be started as soon as possible. The drilling rig will be capable of reaching a depth of between 8000 and 10,000 ft.

FLORIDA

★ Sinclair Oil and Gas Company has reported cores from its deep Monroe County test had shows of heavy oil saturation with occasional bleeding. The No. 1 Williams planned as a Sunniland test to 11,000 ft encountered shows at 9960 ft. Two unsuccessful drillstem tests were attempted. Crews are drilling ahead.

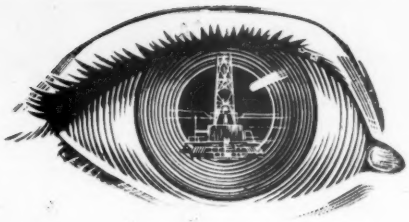
★ Humble Oil and Refining Company's Kirchoff No. 1, Lee County, has recovered 75 ft of oil in a 37-hour drillstem test from 11,819-11,928. There were no gas shows at the surface during the test.

★ On Key Largo, about 40 miles south of Miami, Sinclair has reported some shows of oil around 10,000 ft, in the H. R. Williams No. 1. Company is drilling ahead. Commercial production has not been established.

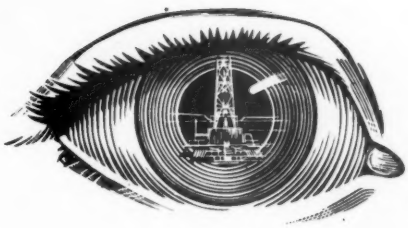
MISSISSIPPI

★ Eutaw saturation in Gulf Refining Companies' No. 1 Chapman Smith Unit, Chaparral field, Wayne County, has been tested for 48 bbl total fluid under swab. Drilled to a total depth of 9710, it was plugged back and casing perforated from 4313 to 4317 ft. Pump will be run and well placed on production. Four more locations have been staked in the area and development of the prospect will proceed immediately.

DRILLING IN SOUTHEASTERN NEW MEXICO is being done by the Makin Drilling Company rig. Picture was taken at Skelly's Caylor No. 5, Lea County, and at the time crew was drilling at 14,153 ft. Above are: A. V. (Pete) Cagle, assistant drilling superintendent, R. (Cotton) Makin, owner, Makin Drilling, and the daylight tour crew, Huey Ingram, driller; H. J. Blount, motorman; D. S. Carson, derrickman; D. L. Wagner, helper, and Dillard Ellington, helper.



drill...



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CORE LAB
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Exploration Activities

LOUISIANA

★ The Texas Company announced that its State Mallard Bay No. 2, has been completed as a producer, opening a new oil field in Cameron Parish, Louisiana. Perforated between 6092 to 6110 ft, the well flowed at the daily rate of 169 bbl of 32.7 gravity oil through a ⅛-in. choke. Tubing pressure was 975 lb and the gas-oil ratios, 381 to 1. The well was drilled to 9205 ft and plugged back. The new discovery well is approximately one mile east of the nearest production, Grand Lake field in Cameron Parish.

★ The North Cankton field of St. Landry Parish enters the news with a new pay discovery announced by the Atlantic Refining Company. Tested on a 7/64-in. choke, the well produced 109 bbl of 36.8 deg oil with a gas-oil ratio of 3110 to 1 at a flowing tubing pressure of 2125 lb. Drilled to a total depth of 9205 ft, 5½-in. casing was set only to 8908 ft and was perforated 8790 to 8800 ft.

★ Completion of the Plaquemines Oil and Development Company No. 1 in a new pay in the South West Pass area of Plaquemines Parish brings to two the producing zones in the field. Completed through perforations from 8280-8310, the well tested 201 bbl of 31.7 deg oil per day. Tubing pressure was 1340 lb and gas oil ratio 377 to 1. Hole was drilled to a total depth of 10,993 ft. Seven-inch casing was set at 9531 and plugged back to 8615 for the completion.

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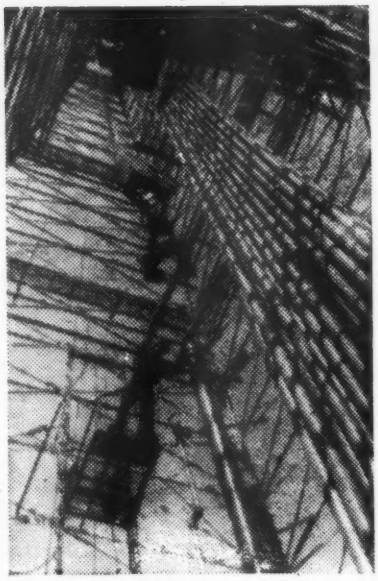

Drilled 14,000 ft in 31 days.

★ More than two and one-half miles of 9⅝-in. protective casing has been successfully set by Shell Oil Company in its Gonsoulin No. 2, an 18,000-ft test currently exploring deep sands at the company's Weeks Island field in Louisiana.

The well, spudded April 25, 1953, was drilled to 14,008 ft in 31 days, including time required to set and cement 120 ft of 20-in. conductor and 3027 ft of 13⅜-in. surface casing. The record-breaking 14,008 ft of 9⅝-in. protective string weighed 673,100 lb and was run in 13 hours after rigging up for casing running operations.

At the present current depth of more than 14,000 ft this new deep test at the Weeks Island field is drilling ahead.

★ Kerr-McGee Oil Industries, Inc., et al, have announced the completion of a flowing well at their No. 1-A State Lease 1997, in the Breton Sound area, off Plaquemines Parish. Perforated in the interval from 5864-5875 ft, the well flowed at a rate of 312 bbl per day on a small choke. Two additional zones of possible production are indicated by electrical log and sidewall cores. Offset operations were begun immediately after the completion of No. 1 well.

★ One and one-half miles west of Houma in Terrebonne Parish the Tide Water Associated Oil Company's discovery in the Hollywood field has been completed as a gas condensate well. From perforations between 12,506 and 12,550 ft the yield was 5,650,000 cu ft a day and 151 bbl of distillate through a 20/64-in. choke. Tubing pressure flowing was 1900 lb. Distillate gravity was measured as 50.1 degrees.

KANSAS

★ Westpan Hydrocarbon Company at its No. 2 Wessell, in Sheridan County, has opened what appears to be a new oil field. Casing was perforated opposite the Kansas City-Lansing limestone from 4086-4090 ft. On a short test the well flowed 26½ bbl of 40-gravity oil per hour before being shut-in.

NORTH DAKOTA

★ Amerada's new Madison lime discovery, the No. 1 Herman May, in Billings County, drilled ahead below 9870 ft in lime, after testing for 324 bbl a day from the Madison between 9402-9466 ft. Test is projected to the Ordovician, expected around 11,500 ft.

★ Warren Petroleum Corporation has completed the No. 1 Anderson in Burke County. On a 24-hour completion test the well flowed 252 bbl of 41.6 gravity oil through a ¼-in. choke, with 410 lb tubing pressure. The well was completed from the zones 8110-8130 ft.

MONTANA

★ Empire State Oil Company's No. 1 Smith, in Roosevelt County, has been tested for 6000 bbl of 41.6 gravity light green oil per day. Production is from two sands. The B-1 from 5746-57 ft produced 2400 bbl a day through a 10/64-in. choke. The B-2 from 5762-75 ft flowed 18 hours through a 10/64-in. choke for an indicated rate of 3600 bbl per day.

★ Sun Oil Company, et al, No. 1 Dynneson has been tested from 12,578-12,605 ft. The well flowed 124 bbl of oil in 24 hours through a 1-in. choke. A later production test through a 12/64-in. choke showed for 94 bbl per day.

ILLINOIS

★ White County received a new field prospect through the completion of Herndon Drilling Company's No. 1 Lamb. In this successful attempt the Rosiclaire sand was tested from 3109-15 ft. Results indicated a producer of approximately 35 bbl per day. In the Roland pool of White County the Pursuit Oil Company's No. 1 Johnson completed in the Aux Vases sand. The 8 bbl a day natural producer was gaged at 70 bbl a day after load oil injected during fracturing was recovered.

OKLAHOMA

★ The No. 1 Vanderpool, George Pasquella's test in Lincoln County, has set casing after successful test of the Second Wilcox from 4427-42 ft. Results of this test were 10 ft of oil cut mud, 90 ft of free oil, and 30 ft of oil-cut salt water, with a shut in bottom hole pressure of 1425 lb. The Hunton lime topped at 4172 ft had showed for 2,000,000 cu ft of gas per day on previous test. First Wilcox showed some staining, but was hard and dolomitic.

★ Ashland Oil and Refining Company, et al, in the No. 1 Velvie Bridal, Logan County, have completed a Prue sand producer. Drilled to a total depth in the Wilcox of 6472, casing was swung and cemented at 5405 ft. Perforated from 5292-5308, well yielded 1¼ bbl per hour through a ¾-in. choke, with 500,000 cu ft per day.

★ Falcon-Seaboard Drilling Company completed a Skinner sand producer in Payne County. Flowing 300 bbl of oil daily through a ¼-in. choke, the No. 2 Embob is producing from open hole from 2990-3003 ft.

★ Carter Oil Company has tested the Misener sand in its Noble County test, the No. 1 Schaffer Heirs. The 63-min test was made in the zone 4985-5033 ft. Gas showed at the surface within three minutes at an estimated 750,000 cu ft per day, and oil was noted at the surface in 20 min. Drillstem recovery was 1110 ft of 44.8 gravity oil. Shut-in bottom hole pressure was 2115 lb. Hole is being deepened for a Wilcox test.

★ Huffman and Malloy have opened a multi-zone gas field in Kiowa County at the No. 1 Hanza. Through perforation from 5696-5752 the well gaged over 2,000,000 cu ft per day on a ½-in. choke. From perforations from 5994-6034 ft it gaged 2,700,000 cu ft per day through a ½-in. choke. Production is from the Springer formation.

CALIFORNIA

★ Tide Water Associated Oil Company announces a wildcat location on Tubbs Island, in Suisun Bay, Sonoma County. The well is projected as a deep test of the area.

★ The Union Oil Company has reported that its deep wildcat No. 92 Torrey, in Ventura County, has been tested in the interval 12,760-13,007 ft. Reported flow was approximately 150 bbl of 30 gravity crude per day, with an estimated 2,000,000 cu ft per day of gas. Well is now drilling deeper.

★ Intex Oil Company's No. 44E, Kern County, has been tested on pump at the rate of 149 bbl of 17.6 gravity oil per day. Production is from sand topped at 2460 ft.

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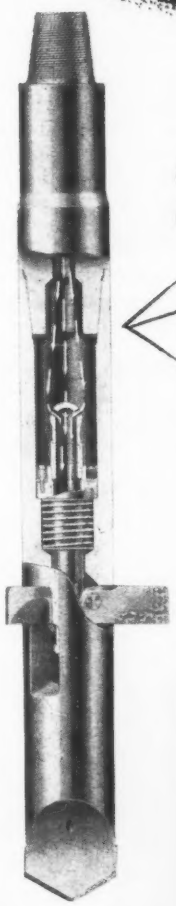

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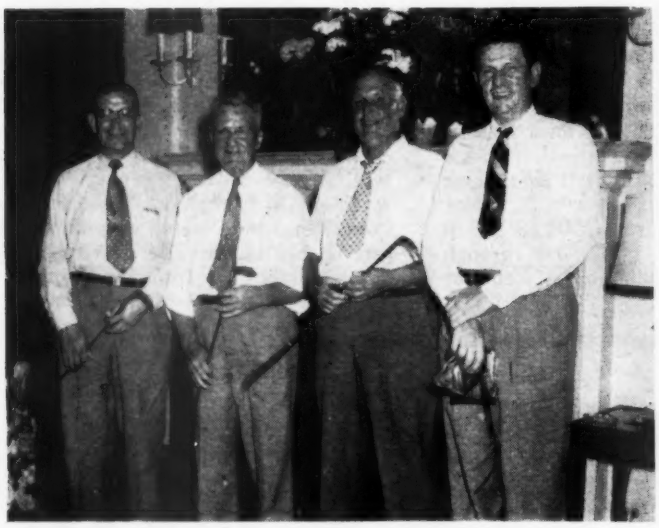
Running Tour With Men in the Industry



NEW YORK NOMADS held their annual golf party at Siwanoy Country Club recently, with about 125 Nomads and guests participating in the tournament. Fewest putts and nearest to pin winners included: G. Rovira, YPF Bolivanos (fewest putts — guest); A. V. Simonson, A. V. Simonson and Company (fewest putts — Nomad; J. Steele, Buckeye Pipe Line (fewest putts — guest), and A. J. Lacock, Foster Wheeler (nearest to pin — guest). Low gross winners were: T. N. Shults, Mid-Continent Supply (Nomad runner-up); A. Cashman, Keenen-Cashman (guest winner); E. F. Gahen, (Nomad winner), and G. R. Weeks, Texas Co. (guest runner up).

▸ **L. E. (Kim) Foust,** Tide Water Associated Oil Company land agent, San Joaquin Valley, was honored by fellow employees at a luncheon upon completion of 50 years continuous service with the company. Foust is the third employee of the Western division to complete 50 years service. He was presented with a service pin and wrist watch by L. F. Bayer, vice president and chairman operating committee.

▸ **Jack R. Fraser** has been appointed chief petroleum engineer for Texas Eastern Production Corporation of Houston, Texas. Fraser, who joined Texas Eastern Production Corporation in 1951 as district geologist, has most recently served the company as division engineer. Before coming with Texas Eastern Production, Fraser was associated with Shell Oil Company as production geologist, division, in Oklahoma City, Oklahoma. He was graduated with a BS degree from the University of Pittsburgh.

Harry R. Moseley has been appointed Gulf Coast division superintendent for Texas Eastern Production Corporation. Moseley, who joined the company in December, 1951 as district petroleum engineer in the district office in Shreveport, Louisiana, was transferred to the Houston office in December, 1952. Before coming with Texas Eastern Production Corporation, Moseley was associated with The California Company as a petroleum engineer in Brookhaven, Mississippi. He was graduated from the Louisiana State University.

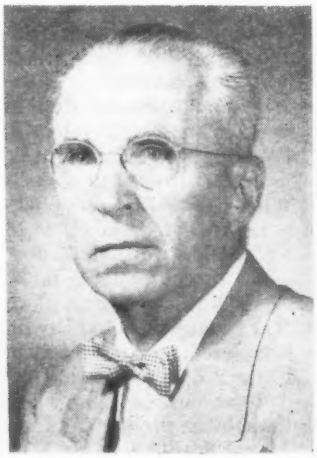
▸ **H. W. Straley, III,** geologist and geophysicist, Princeton, West Virginia, spent the field season of 1952 investigating chromite deposits in the state of North Carolina.

▸ **Charles A. Chipman,** Bolivar, New York oil producer has been named president of the Pennsylvania Grade Crude Oil Association. He is the first president from the Allegany County, New York, oil field. He succeeds **Clarendon E. Streeter,** Bradford producer, who completed four one-year terms at the head of the cooperative, non-profit group of Pennsylvania grade oil producers, refiners and marketers. He served in World War I as field artillery captain.

Chipman has been a vice president and director of the organization. He has lived in Bolivar and been in the oil business there since 1918. He is a partner in the following oil companies: Reynolds and Chipman, Star Oil Company, Victory Oil Company, W. A. M. Oil Company, H. J. Reynolds and Company, Hickory Oil Company, Chipman and Herrick, Reynolds and Reeland, and Petre and Amesbury Drilling Company.

W. A. Sloan, regional treasurer, L. F. Bayer, and L. E. Foust.

J. R. Fraser



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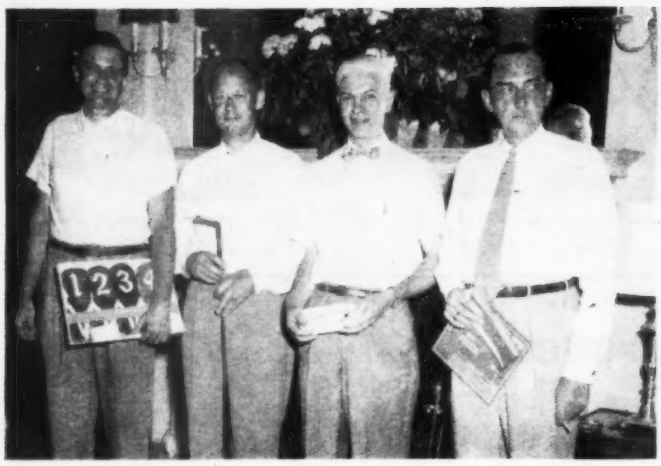


LONGEST DRIVE and high gross winners of the NY Nomads golf tournament were: R. W. Byrholm, Aramco (longest drive — guest); Herb Maland, R. J. Eiche & Associates, Inc. (longest drive — Nomad); W. Martyn, Burns & Roe, Inc. (high gross — guest), and E. E. Andreason, George P. Gregory, Inc. (high gross — Nomad). Low net winners: H. T. Leonard, Midwest Pipe & Supply (guest winner); John D. Evans, Lucey Export (I. Frank Brown trophy), and W. P. Curley, Tube-Turns, Inc. (Nomad runner up).

▸ **R. A. Broding** has been named as vice president of Century Geophysical Corporation, Tulsa, Oklahoma. Broding is a graduate of St. Johns University after taking work in pre-engineering at Minnesota University and communications at Southern Methodist University. He joined Magnolia Petroleum Company in 1939.

Century manufactures complete truck mounted and portable seismic equipment as well as oscillographs, galvanometers, vibration, and stress analysis equipment and other special instruments for industry.

▸ **E. G. Dobrick, Jr.,** has been transferred to the Standard Oil Company of California as chief geophysicist.

W. D. Lynch is being appointed Eastern regional geologist with headquarters in Mattoon, Illinois. He will be in charge of that office and responsible to the chief geologist in New Orleans for the geological work throughout the north central and eastern states formerly under Dobrick's direction.

▸ **A. E. Hoffman,** Lake Charles, Louisiana, formerly superintendent of Sunray Oil Corporation's South Louisiana and Corpus Christi district operations will be transferred to Midland, Texas, to be superintendent for production in the North and West Texas district, succeeding **Perry A. Gill,** who has been transferred to Tulsa general offices to be Sunray's purchasing agent.

Keith Lindley, Lewisville, Arkansas, formerly Sunray's tri-state district superintendent, will be transferred to Lake Charles as district superintendent for South Louisiana.

Fred M. McDaniel, Midland, Texas, formerly assistant district superintendent, will move to Lewisville as tri-state district superintendent.

Carl E. Wilson, Alice, Texas, formerly superintendent of the company's South Texas district, has been named superintendent of the newly enlarged Gulf Coast district encompassing two areas formerly operated as separate Corpus Christi and South Texas districts. Wilson's headquarters will be at Alice.

Frank E. McClatchey, Corpus Christi, and **Fred S. Goddard,** Alice, both formerly assistant district superintendents, will retain these positions with enlarged responsibilities for the Corpus Christi and Alice, Texas, operations areas respectively.

Loyd L. Peek, Snyder, Texas, formerly Scurry County area field superintendent, is being transferred to Midland as assistant superintendent to Hoffman for Sunray's North and West Texas district.

SOME 300 LOS ANGELES NOMADS attended the chapter's 14th annual Whing Ding at the Riviera Country Club in that city recently. The affair opened with a golf tournament, and shown above are Jim Hughes, Lane Wells, presenting President's Cup for low gross score by a Nomad to Knight Templeton of S. R. Bowen Company. Young lady is one of the entertainers. At right are: Back row, Warner Parker, Oil Well Supply; H. Said, Union Oil; Karl Kreiger, Richfield Oil; C. Johnson, Servecio Thomas, Venezuela. Front row, Red Radke, Hughes Tool; John Rife, Web Wilson; Art Titus, General Petroleum, and Ben West, T. P. Pike Drilling.

R. M. Miller has been named assistant manager of the Los Angeles production division of The Ohio Oil Company. **W. T. Kennedy** has been appointed division superintendent of production of the Los Angeles division succeeding Miller. Both men will continue to be located in Bakersfield, California.

Miller's recent appointment comes on his 48th anniversary with The Ohio Oil Company. He began his continuous employment with Ohio Oil in 1905 as a pumper in Alexandria, Indiana.

Kennedy joined Ohio in 1930 at Stephens, Arkansas, where he had been employed as a foreman with the Transcontinental Oil Company.

Milan G. Arthur, Union Oil Company, has been named chairman of the Pacific Coast district, American Petroleum Institute, Division of Production. Election was held at the group's annual spring meeting in the Statler Hotel, Los Angeles, recently. Arthur succeeds **T. H. Acres,** Sunray Oil Corporation, Los Angeles.

Other Pacific Coast district officers elected at the business meeting were: **J. T. Ledbetter,** vice chairman, Los Angeles Basin, Union Oil of California; **G. V. Kersten,** vice chairman, South San Joaquin Valley, Western Gulf Oil Company; **Watt Lupton,** vice chairman, Coastal area, Shell Oil; **Jack Lemley,** vice chairman, Coalinga-Kettleman, Standard Oil Company of California; **Charles T. Reichert,** treasurer, National Supply, and **Mrs. Elsie Edmiston,** secretary, American Petroleum Institute, Los Angeles.

Lot Bowen, of Western Gulf Oil, was elected chairman of the District Advisory Committee.

James McNeill, Union Oiler from 1933 to 1950 and since that time with Wilshire Oil Company as manager of drilling and production, and with **Tevis Morrow** in a similar capacity, has entered into consulting practice with headquarters in the Subway Terminal Building, Los Angeles. McNeill is a graduate of University of Southern California, with post graduate work in mechanical engineering from Penn State. He was assistant to the vice president when he left Union Oil Company and he has had a wide experience in the diverse phases of drilling and production, in California, West Texas, and the Rocky Mountains.

Harry A. Buchanan, formerly superintendent of field operations for Bell and Burden, Inc., drilling contractors, has been elected vice president of the company, according to an announcement by A. H. Bell, president. Buchanan, a native of Santa Barbara, was active in the Santa Fe Springs boom of 1929, where he functioned as driller for George F. Getty; was for a number of years with Kettleman North Dome Association at Kettleman Hills; and prior to joining, the Bell and Burden organization was northern district superintendent for Loffland Brothers. He will continue his headquarters in Ventura.

INTERNATIONAL GUESTS at a recent LA meeting of Nomads included: Standing, B. de Beaumarchais, S. N. Repal, Algiers; Milton H. Hobbs, Standard Vacuum, Sumatra; V. C. Dabbs, Mene Grande Oil, Venezuela; Thomas D. Foster, Standard Vacuum, Sumatra; J. C. Bazinet, Aramco, Saudi Arabia; L. Hahn, Wintershall Emsland, Germany; E. C. Mahmoodian, D. & E., Iran; Josip Vuckovic, Naftaplin, Yugoslavia. Sitting: Jim Worsdall, National Supply, Venezuela; F. Leca, S. N. Repal, Algiers; R. Samizdeh, D. & E., Iran; Robert S. Hall, Petro-Tech, Venezuela; Bob Grebe, Baker Oil Tools, Venezuela; I. Eklund, Johansson y Cia., Bolivia, and H. Haydarpoor, D. & E., Iran.

C. F. Stephenson, formerly superintendent of Magnolia Petroleum Company's Pegasus producing district in West Texas, has been promoted to assistant division superintendent of the Oklahoma division with headquarters in Oklahoma City.

Kenneth R. Joynt has been transferred from superintendent of Magnolia's Vanderbilt producing district to the Pegasus district as district superintendent.

John S. Russell has been promoted from assistant superintendent of the Chase, Kansas, district with headquarters at Kimball, Nebraska, and transferred to the Vanderbilt producing district as district superintendent.

Clarence E. Taylor, formerly superintendent of the Alice, Texas, producing district, has been transferred to superintendent of the Cushing district with headquarters at Drumright, Oklahoma.

J. R. Posey, who has been superintendent of the Cushing producing district, has been moved to Alice where he will be distict superintendent.

John C. Fry has been promoted from driller to drilling tools foreman in Magnolia's Gulf Coast drilling tools district, and **Aubrey B. Cannon** has been promoted from driller to drilling tools foreman in the same area.

William A. Sherman has been promoted from marine drilling tools foreman to marine drilling tools supervisor in Magnolia's Louisiana-Gulf district.

Forrest B. Farmer has been promoted from assistant production foreman to foreman in Magnolia's Brownfield, Texas, producing district.

Earl D. Hughes has been advanced from pulling unit operator to assistant foreman in the Brownfield district.

NEW MEMBERS were inducted into the Los Angeles Nomad Chapter at its regular meeting recently, by Dick Winder, left, and Joe Schlarb, right, both of Chiksan Company. New members include: Tom R. Ashe, Globe Oil Tools; Harry M. Taylor, Bettis Rubber; Bill Brooks, Byron Jackson, and Allen Hicks, Hydril Company.

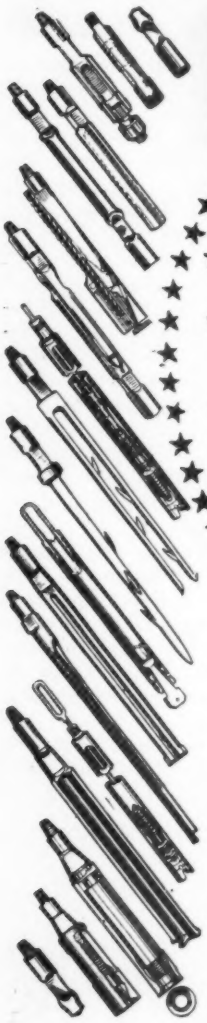
Running Tour

Alvin P. Loskamp has become associated with E. B. Noble, petroleum consultant. Loskamp was graduated with a BS degree from University of Syracuse in 1921; took post graduate work at Stanford graduating with a geological degree in 1923.

Since 1926 he has been in the Permian Basin of West Texas and New Mexico. He was for a time district geologist in Midland for the Barnsdall Oil Company. Later he was manager of exploration for Union Oil Company of California in West Texas from which he was promoted to general manager of the West Texas-New Mexico division. Since 1950 he has practised as geological consultant in Midland.

Fred Wilcox has been named an engineer in the evaluation section of the production division, Deep Rock Oil Corporation Eastern Kansas district. Wilcox's new job as intermediate engineer will include supervision of field development and construction in the Eastern Kansas district. Wilcox, a University of Tulsa graduate, joined Deep Rock in 1950.

Simultaneously is announced the return of **H. E. Cobb, Jr.,** to the company following service as a lieutenant in the U. S. Navy in the Korean area. Cobb joined the company in 1949, and has been named intermediate engineer in the production division's evaluation section.



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F. C. Culbertson, Jr., Humble Oil and Refining Company senior petroleum engineer, Thompsons district, Gulf Coast division, was transferred to the Imogene district, Southwest Texas division.

W. E. Buckner, roustabout gangpusher, Odessa district, West Texas division, moved to Winters district, North Texas division.

Walter Clifton Cornelison, assistant district chief clerk, Pickton district, East Texas division, transferred to the Maurbro district, Gulf Coast division.

Robert Grey Hindman, civil engineer, was transferred from the Gulf Coast division office, to the California area office.

R. H. Suman, petroleum engineer, Stratton district, Southwest Texas division, transferred to the Thompsons district, Gulf Coast division.

J. C. Taylor, Jr., associate petroleum engineer, petroleum engineering division office, Houston, moved to Hobbs district, West Texas division, as petroleum engineer.

J. A. Sizer, district chief clerk, Mallalieu district, Louisiana, was transferred to the Maurbro district, Gulf Coast division.

J. J. Martin, assistant district chief clerk, Friendswood district, Gulf Coast division, was promoted to district chief clerk at Mallalieu district, Louisiana division.

T. W. Bynum, Jr., assistant district chief clerk, Maurbro district, was transferred to Friendswood district, Gulf Coast division.

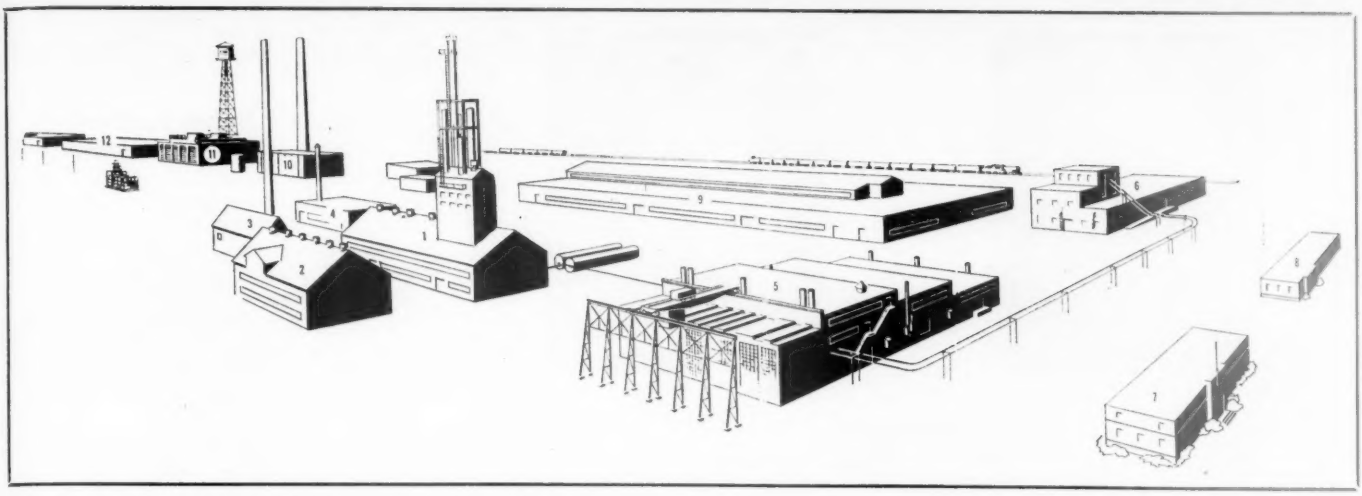
Kurt F. Wendt, professor of mechanics and since 1948 associate director of the Wisconsin Engineering Experiment Station, was named dean of the University of Wisconsin College of Engineering by the UW Board of Regents. Wendt, who returned recently from a 20-day flying trip to India to conduct a technical education and research survey for the U. S. State Department, succeeds Dean Morton O. Withey who retired July 1.

Herschel M. Glasgow has been named geologist for Houston Natural Gas Production Company's Houston district.

The production company is the wholly owned subsidiary recently formed by the Houston Natural Gas Corporation, a utility which serves a 20-county area along the Texas Gulf Coast.

A graduate of Texas Christian University, Glasgow is a member of the Houston Geological Society and the Society of Exploration Geophysicists. He was with Standard Oil of Texas for five years before joining the gas company.

Tom L. Holland is now associated with the Crawford Drilling Company in the capacity of drilling superintendent. He previously served as drilling superintendent for L. D. Cain Drilling Company for approximately two years, was also associated with Houston Oil Field Materials Company approximately 10 years; ultimately serving in the capacity of division manager in charge of fishing tool department.



Artist's drawing of new high pressure polythene plant.

Ten Tons Pressure in Polythene Plant

World's highest industrial process pressure of 20,000 psi will be maintained when Alberta plant begins production this autumn

J. D. WRIGHT and J. H. SHIPLEY

HIGHEST pressures known to be used in any industrial process throughout the world—more than 20,000 psi—will become "routine" this coming autumn, when the polythene plant of Canadian Industries Ltd., now approaching completion in the environs of Alberta's capital, Edmonton, begins production. Pressure to be exerted as a matter of work-a-day operation will be exactly equivalent to that of a giant "6200" class railroad locomotive pushing with all its might against a solid wall. It is that herculanean concentrated downward force that actuates formation of polythene from ethylene in the C I L plant's reaction vessels.

The process begins at the Leduc wells, where wet gas is drawn off and sent to the Imperial Oil Company conservation plant at Devon to be treated. From this plant, a dry gas is delivered by pipe line to Edmonton, for use as fuel. This dry gas contains approximately 20 per cent ethane, along with other hydrocarbons in gas form.

Pure Ethylene From Raw Gas

Before the actual polythene process can begin, ethylene of high purity must be prepared from the raw material gas. Dry gas in the Devon-Edmonton pipe line will be piped through a metering station to the ethylene section of C-I-L's plant, a unit designed to remove ethane from the dry gas and then change the ethane into ethylene from which the polythene is produced. After ethane has been removed, the gas remaining is returned to the city distribution mains. Although ethane has been removed the heating qualities of the residual gas are still satisfactory.

In the ethylene plant, ethane is removed from the gas by using a "sponge oil" which "absorbs" ethane. The "sponge oil" is next stripped of its ethane content and the ethane cracked by passing it through alloy steel pipes in a gas fired furnace.

The resultant ethylene product is separated by fractional distillation, purified, dried, turned into a liquid and finally stored under pressure. Many of the operations are carried out in a series of tall distillation columns of the type familiar in petroleum refineries.

Some Hydrogen for Plant Fuel

Hydrogen gas produced in this process, together with some of the remaining gaseous hydrocarbons, will be used as fuel at plant, balance being metered and returned to distribution pipe line.

The pure ethylene will go to the polythene plant proper for compression in a series of huge gas compressors, some of them driven by machines of more than 600 horsepower each. Because of the high pressures, not only the compressors, but, also, all the pipe lines, valves and associated equipment have to be of massive construction.

EXCLUSIVE

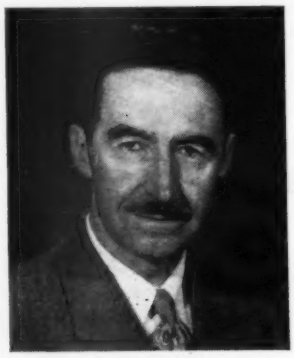
At the same time the highest precision workmanship is necessary to eliminate all risk of leakage or distortion. Under this extremely high pressure, ethylene is fed into the reactor, in which part of it undergoes the extraordinary change into polythene.

The conditions of temperature and pressure in the reactor itself have to be controlled carefully to maintain constant quality. The product must be removed from the reactor as fast as it is formed, in order that the process may be carried on continuously. All these operations are conducted by remote control because of safety considerations.

Emerges Fluid as Molasses

Polythene, after separation from the unchanged ethylene, which is recompressed, to be used again, will emerge at a temperature still above its melting point, in a viscous water-white form, about as fluid as molasses. This will be chilled and chopped into pellets or "flake" about the size of grains of wheat, ready for transfer to large storage bins in the warehouse. From there it will be packed, 50 lb at a time, into multi-wall paper sacks by means of the latest mechanical equipment, ready for shipment in box-cars to the consumer market.

The elaborate arrangement of sensi-



J. D. Wright

J. H. Shipley

The Authors

John D. Wright, manager of the Edmonton Works of Canadian Industries, Ltd., is a graduate of the University of Toronto, joining Canadian Industries, Ltd., as a chemist in 1929.

From that year until 1945, he held various positions with C-I-L and Defense Industries, Ltd., a wartime subsidiary.

From 1945-52, he was at Windsor, Ontario, first as manager of the salt plant operated by C-I-L, then as assistant manager and finally manager of the consolidated salt and chemical works. In February, 1952, he was appointed manager of the Edmonton Works, expected to be completed late in 1953.

Dr. John H. Shipley is division manager, polythene division, Canadian Industries, Ltd. He joined C-I-L in 1938, and went to Nobel Works of Defense Industries, Ltd., a subsidiary of C-I-L in 1940 as chief chemist, advancing to general superintendent of production. He left Nobel in 1945, to return to C-I-L as chief chemist of the explosives division, Beloeil, Quebec, moving through acting development manager, organic chemicals; assistant division manager, chemical group; manager, development division, chemicals department; to his present position. He received his BS and MS degrees from the University of Alberta, and his PhD from McGill University.

tive instruments, multitude of automatic control devices, and the engineering skill employed in design and construction of the equipment will combine to make this one of the most complex process units to be found anywhere in Canada's industry.

Polythene, now one of the most widely used plastics, began life as the curiosity of an "unsuccessful" research experiment. It was not destined, however, to remain a curiosity long. It quickly rose to become a major contributor to Britain's defense against enemy air attack in World War II.

Stems From Research in England

The story begins in 1933 in a research laboratory of Imperial Chemical Industries Limited, in England. Two research scientists, R. O. Gibson, and E. W. Fawcett, were studying the influence of extremely high pressures on a variety of chemical substances and chemical reactions. One experiment seemed to end in failure. They were trying to make two different chemicals react when placed together under pressure. One of these, ethylene, was a well-known component of ordinary coal gas. It is also found in oil refinery gases and can be made from natural gas taken from the ground. But the two chemicals did not react as expected. Instead, the reaction vessel was found to contain a small amount of a new, white, wax-like substance, formed somehow under pressure from the ethylene. It was this white substance which was to become known as polythene.

Years of experimental research followed to study the conditions needed for controlling this reaction. Whenever ethylene had previously been subjected to high pressures, it had exploded, leaving only a black carbon residue. Explosion-proof equipment had to be designed so that enough polythene could be collected to study its properties.

Fifth Test Yielded Polythene

As soon as reasonably explosion-proof equipment was built, experiments were resumed. Again a wax-like solid was left behind in the vessel. But three succeeding atempts ended in explosions. A fifth trial produced the desired product and the experimenters were on the way to providing commercial polythene.

Early studies showed that polythene was tough and, at the same time, flexible, even at sub-zero temperatures. It proved to be lighter in weight than any other known plastic, and tasteless, odorless, and non-toxic. Polythene also was found to be unaffected by practically all solvents and chemicals and was impermeable to water.

One set of properties quickly proved of vital importance. Polythene had excellent electrical insulating qualities. As a result, the first commercial polythene was planned for use as electrical insulating material in high-frequency radio connectors, communication cables, and the like. Many other uses were also foreseen.

The war intervened. By coincidence the first plant to produce polythene for commercial use started production in England the same day on which the Germans invaded Poland, September 1, 1939. War needs took all the plant's production from the start and no polythene for civilian use was available until 1945.

Supreme Value in Radar

Polythene made a key contribution to Allied victory, because it met a need for high-frequency insulation in radar equipment for which no other material could serve so well. Sir Robert Watson Watt, celebrated pioneer in radar development, has written that the introduction of polythene "transformed the design, production, installation and maintenance problems of airborne radar from the almost insoluble to the comfortably manageable."

Several factors led to the decision to build the Canadian plant at Edmonton. Consideration had been given at one time to making polythene from the non-condensible off-gases from oil refineries either at Sarnia, Ontario, or at Montreal. This would have brought the plant nearer to its largest market area. It was felt, however, that the supply of ethylene from these sources would be too closely tied to the production of other refinery products and that the fluctuation in demand for these other products would affect the continuity of supply of ethylene.

Composition of Leduc Gas Best

The alternative lay in building a plant near the Leduc-Woodbend oil-field close to Edmonton. Gas from this field has a peculiarly appropriate composition for making polythene since it contains a high percentage of ethane from which ethylene, the base for making polythene can be derived.

The advantages of manufacturing in eastern Canada, close to the market, were outweighed by the advantages of the Edmonton site. Additional freight charges could be offset by a virtually unlimited supply of raw material at lower cost. Fuel also was less expensive.

Plant construction began April 1, 1952, after a period of extensive planning. The site is approximately one mile from the city limits on Highway 16, in the Municipal district of Strathcona. Present plans call for the plant to start operations on October 1 this year. Only part of the plant will get into production on that date. The remainder will follow as construction is completed, some months later.

Construction of the main buildings is well underway. Both the ethylene plant and the main reactor building are taking final shape and installation of equipment has begun. About 650 men are being employed by the Poole Construction Company Ltd. on the construction operation.

Ideal Working Conditions Provided

The plant will provide its employees with the latest in modern working conditions. The "last word" in safety planning is being effected. A hospital and first aid center will be outfitted with up-to-date medical equipment for the care of employees. A full-time nurse will

Polythene plant of Canadian Industries, Limited on threshold of Alberta's capital city and industrial and oil-and gas center, Edmonton. In center foreground, main reactor building; at left, ethylene plant, compressor house, cracking furnaces, and control room.

be in attendance and a physician will be available part-time.

Edmonton and the western provinces will be well represented on the staff of the new plant. About 230 employees will be needed when full capacity is reached. A staff group of some 65 people will consist of 21 technical personnel—engineers and chemists—as well as about 15 foremen, with the remainder made up of clerical personnel. The payroll work force will have approximately 80 operating and 85 maintenance personnel.

Except for a few specially trained mechanics, all the payroll staff will be hired in the Edmonton area. Initially most of the trades foremen will have to be brought from other industries in eastern Canada and be specially trained in England. Production foremen will be men from other C.I.L. plants and from Edmonton. Almost all the clerical staff will come from the city and district.

Technical Staff Britain-Trained

Many of the technical staff have been given extensive training at an established polythene plant in England. Maintenance foremen and mechanics now on the plant site installing special equipment spent several months in England, last year, learning about the job.

The technical staff will be drawn largely from existing C-I-L plants, but many will be former Western Canada residents returning home. Overall operations have been under the direction of Dr. John Shipley, C-I-L's polythene division manager in Montreal, who was brought up in Edmonton, where his father was professor of chemistry at the University of Alberta.

J. D. Wright, who will be manager of the plant, was works manager of C-I-L's chemicals plant at Windsor, Ont. Production superintendent Stewart McArthur is also from Edmonton and a graduate of the University of Alberta. K. R. Nelson, accounting supervisor, W. J. Plank, project engineer, and B. A. Radford, chemical engineer, all hail from Edmonton, while chemical engineer H. A. Burns comes from Didsbury, Alberta.

Others from the west include: Employment supervisor, R. J. Gallivan, from Calgary; H. R. Grass, assistant polythene supervisor, Regina; J. D. Sansum, maintenance supervisor, Vancouver; and J. W. Crowe, works accountant, Winnipeg.

Polythene's vital but narrow wartime role gave only a scant indication of the important place it would take in a peacetime economy. A great number of new uses were developed following war.

Resin and Film From Flake

As the demand for polythene expanded, C-I-L, who had been importing both polythene resin and film for sale in Canada, decided to set up a plant for making polythene film and tubing at Shawinigan Falls, Quebec. This plant was opened in the spring of 1950, using imported polythene flake as its raw material.

Soon it became apparent that the Canadian market would support a plant for making polythene flake itself and studies began which ended in the decision to construct the plant at Edmonton.

Industrial packaging has found a place for polythene film. For example, automobiles shipped from England are being wrapped in a polythene film envelope to protect them against the corrosion of sea air.

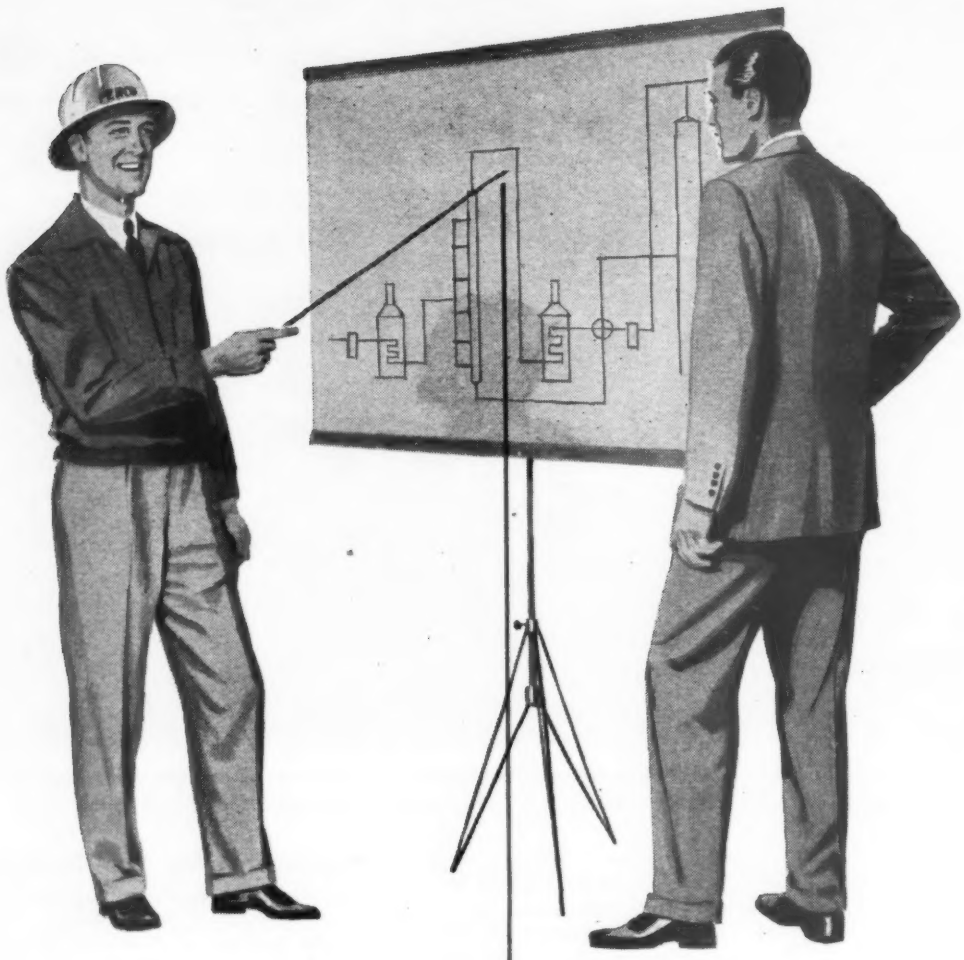
Polythene Piping Non-Corrosive

Use of polythene for piping is of special interest to Western Canada farmers. The problem of corrosion with galvanized iron piping laid underground is particularly acute in some alkaline prairie soils. Some ground water is also sufficiently acid to attack galvanized iron. There is no danger that galvanic corrosion will result in deterioration if polythene pipe is connected to existing metallic pipe systems.

Polythene piping is resistant to chemical activity and can be laid in the ground without fear of deterioration. Its lightness and flexibility make pipe laying a simple, one-man job and polythene piping can be readily moved from one location to another as needed. As the polythene is not brittle, it is not broken by freezing. Polythene is the only plastic piping that is highly flexible and yet rigid enough to keep its form under pressure of earth.

Temporary water services required for livestock or irrigation on the farm are natural uses for polythene pipe. Accidental damage to the pipe is quickly and completely repaired with such simple tools as a jacknife and a screwdriver and clamped with an ordinary hose-coupling strap. Polythene piping can be left out all winter without danger of splitting from frost.

Polythene is fast finding an increasing place in articles for home and industrial use. It is believed the Edmonton plant will make an important contribution to the Canadian economy in supplying polythene flake for conversion into the many uses which will help increase the Canadian standard of living to a great extent. * * *



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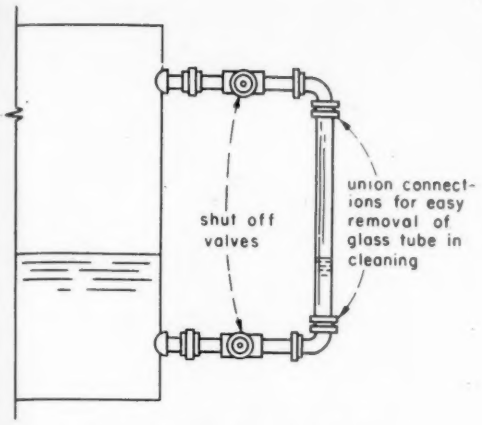

FIG. 1. Typical gage glass installation.

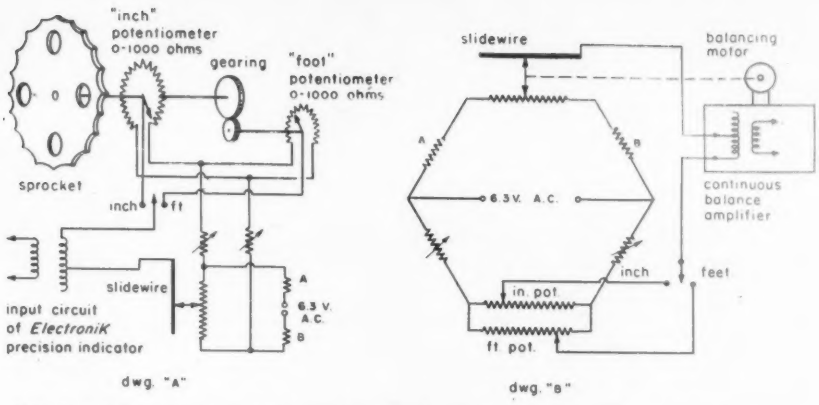

FIG. 2. Wiring diagram and associated schematic of tank gaging device.

Trends in Refinery INSTRUMENTATION

PART 10--Liquid level measurement and control

S. D. ROSS* and W. W. DRAKE*

THE big three of the many variables under measurement and control in present day processing plants are, by general agreement, temperature, pressure and flow. Running a close fourth in incidence and importance as a measured variable is liquid level.

Historically, however, liquid level is the veteran of them all. It was undoubtedly many thousands of years ago when man first threw rocks and rubbish into a stream, making a crude dam, and thus building up a water level in a place of his choosing. A stick, notched or calibrated in some manner, satisfied those curious about the height of water behind the dam.

The need for a means of liquid level indication more refined than a notched dip-stick was met when someone remembered that "Water seeks its own level." This first instrument engineer connected a glass tube to the open vessel containing the liquid in question, and noted the level inside the vessel by the level in the glass tube. For closed vessels not at atmospheric pressure, the upper, or open end of the glass tube was connected to the vessel at the top, so that pressure inside the vessel also existed in the level tube. The gage glass (Fig. 1) and its various modifications (reflex, etc.), that we know today differs very little from this first arrangement.

The purpose of this paper, however, is not to give a history of the development of liquid level instrumentation, but to describe the operation and application of such instrumentation to the process industries, and in particular, the petroleum industry.

The various systems of liquid level instrumentation fall into four main classifications: Free float devices, displacement-float mechanisms, hydrostatic pressure methods, and electrical and electronic methods. Each system is treated separately in this paper, with factors of measurement, control, installation, and maintenance taken up concurrently with the particular system or method.

Free Float Devices

The simplest of all float gages is the ball and tape, (or ball and cable), with the free end of the tape counterweighted and equipped with a pointer. By a suitable arrangement of pulleys the pointer may be made to travel along the face of a vertical, calibrated strip, indicating the level of liquid in the vessel as the float rises and falls. Such an arrangement works satisfactorily for vessels of almost any height, and is found in wide usage today with open vessels. The inconvenience of having the pointer at the top of the scale when the tank liquid is at a minimum level, and at the bottom when the tank is full, can be avoided with a suitable pulley arrangement.

With large vertical scale strips, and large contrasting scale markings, it is easily possible for an observer to check levels on many tanks, and at a distance. With the observer close by, accurate reading is of course impossible, because of parallax error when the pointer is near the top of the scale, many feet above eye level.

Some means for transmission of the position of the float is necessary, then, for greater accuracy, and for convenience, when the level of many tanks must be gaged. Checking levels by walking around a farm of 30 to 40 tanks is time consuming as well as tiring — two disadvantages overcome by centralized indication.

Remote Indication of Float Movement. One of the simplest ways to transmit information over long distances is by electrical impulses through wire connection. At such distances, air transmission is impractical, as well as having a much higher installation cost. It is also said by some that electrical impulses are much easier to handle at the receiving end, and that a greater variety of control or other actions can be initiated by these signals than is possible with air signals.

In practice, the two main methods for remote indication of liquid level as detected by ball float mechansims are based on electrical transmission. The first is a relatively simple device using two precision potentiometers (variable resistances), whose shafts are rotated a certain number of degrees by the extent of rise or fall of the float, and which are electronically connected into an a-c Wheatstone bridge. A four-wire cable leads from the bridge circuit to the *ElectroniK* precision indicator (Fig. 4) used as the detecting and indicating device. Accuracy of the device is ⅛th in. in 50 ft.

*Brown Instruments Division — Minneapolis-Honeywell Regulator Company.

EXCLUSIVE

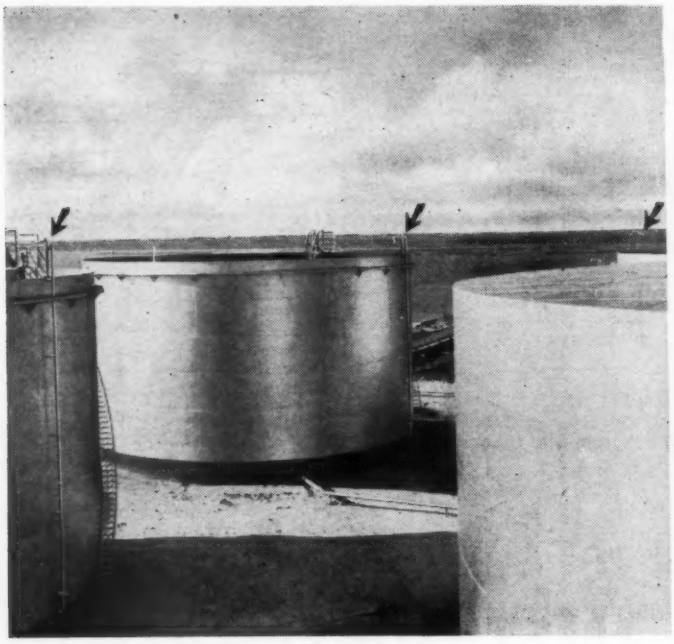

FIG. 3. View showing tank gage installation.

FIG. 4. Operator reading tank depths and temperature at *ElectroniK* precision indicator.

The system, as designed by the Shand and Jurs Company is shown diagramatically and schematically in Fig. 2. The housing for the sprocket and transmitting potentiometers can be seen near the base of the tank in Fig. 3. Operation is simple and straight forward, with the "foot" potentiometer making one complete revolution in 50 ft of tank height, and the "inch" potentiometer one revolution per foot. Since the resistance of each is 1000 ohms, and they are connected in parallel, only one slidewire is necessary in the *ElectroniK* precision indicator. A simple switching device connects either the "foot" or the "inch" sliding contact into the circuit. The small variable resistors are used for initial zeroing and adjustment.

System Using Synchronous Motors *(Selsyns)*. A second system for remote indication of float travel by electrical means is quite similar to the first as far as the mechanical arrangement at the tank or vessel is concerned. A perforated tape or some other method is used to give positive coupling to a sprocket or drum, which in turn is mechanically linked to the rotor of a transmitting selsyn. Five wires (two for the rotor and three for the stator) connect the transmitting selsyn to a receiving selsyn. As the rotor of the transmitter is turned, the rotor of the receiver follows in exact angular displacement. A pointer attached to the shaft of the receiving rotor indicates float position or liquid level. Suitable gearing arrangements may be used to increase the range of the system or increase its accuracy.

This method has a number of disadvantages. For example, a five-wire cable is necessary, initial zeroing is difficult for persons unfamiliar with synchronous motors, exact phase relationships must be maintained for accuracy, and, in event of power interruption, serious errors may appear when power is restored. Perhaps the most important disadvantage is that a separate receiver is required for each tank transmitter, unless a complex switching arrangement, subject to many possible faults, is employed.

Maintenance. Maintenance of float and tape devices is generally confined to periodic examination of the tape or cable connecting the float and sprocket. Systems using stranded cable are subject to untwisting and fraying, which of course usually causes snags in the pulleys and gearing. As visual indication of level is provided at the tank by the Shand and Jurs device, the electrical transmission and indicating portion can be checked by comparison. With multiple installations, periodic cleaning of switching contacts is necessary. Occasional lubrication of the gearing should be carried out according to the manufacturer's instructions.

Some operators have found it worthwhile to replace a stranded cable with solid stainless steel wire of about number 8 gage. Besides avoiding trouble caused by fraying, it is felt that the stainless steel is more desirable through its corrosion resistance and greater strength.

Liquid Level Control Using Free Float Devices. With the standard of living as high as it is in America, it seems safe to assume that most of us are familiar with what is often termed "modern plumbing." Perhaps the sparks were kindled in the breasts of many now famous instrumentation authorities by childhood wonder at the intricacies of the lever and brass ball of the water closet. Certainly it is the example that first comes to mind when one thinks of liquid level control by free float devices.

Such simple close-coupled control systems are in use in refineries and processing plants today. They can be used in open vessels or in vessels under moderate pressure, and although their range of operation is fairly limited, they provide an inexpensive means of keeping level within specified limits.

The usual mechanical arrangement (see Fig. 5) of the device is a metal ball attached to a rod, with the rod attached to a rotary shaft turning in a bearing, trunnion, or packing gland. Coupling to the control valve can take many forms, some purely mechanical, some using standard pneumatic methods such as flapper, nozzle, and pilot relay.

Power Available from Ball Floats. The amount of power developed by a ball float is a function of the allowable displacement of liquid around the circumference of the float ball. For this reason ball floats are weighted so that the ball rides half submerged in the

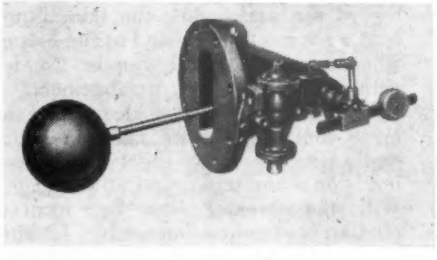

FIG. 5. Internal float mechanism.

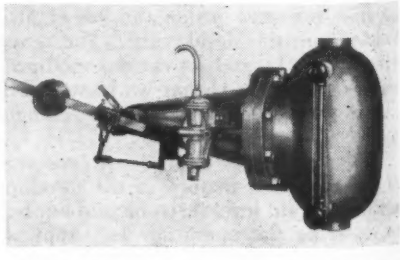

FIG. 6. External cage float machanism.

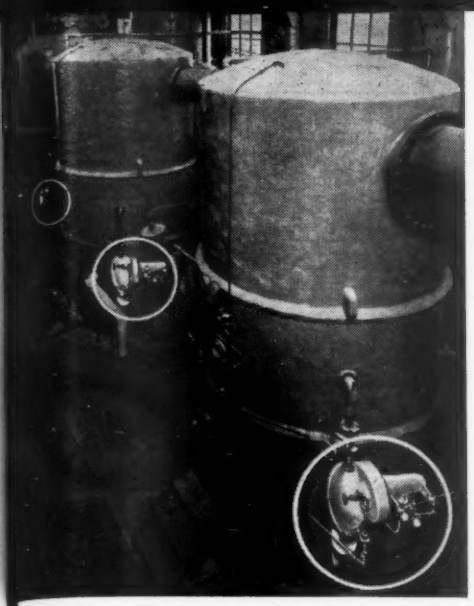

FIG. 7. Typical float cage installations.

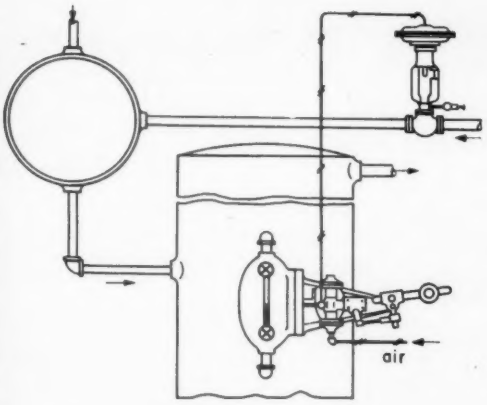

FIG. 8. Float cage installation with pneumatic pilot relay.

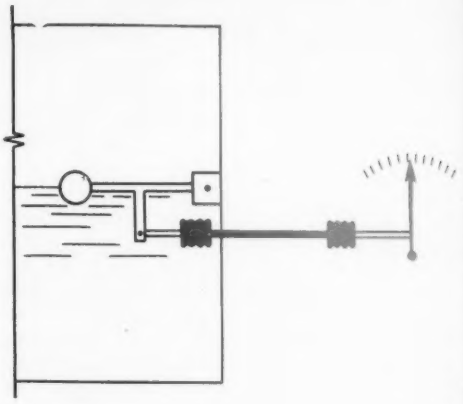

FIG. 9. Hydraulic system for remote indication.

liquid, its circumference being greatest at the half-way point.

The power available from the float control system is the product of the buoyant force developed by ball displacement and the length of the connecting rod. Usually it is not practical to have a system with large diameter floats or lengthy connecting rods, and for this reason applications of float valves (mechanically linked) are somewhat limited. Friction offered by packing glands and linkages is only part of the trouble; differential pressure drop across the valve member causes much of the power available from the float to be used in overcoming these velocity forces. Stroke or travel of the valve is limited in practice usually to ½-in. or ¾-in. movement.

Float Cage Devices. A popular method for liquid level control in pressure or vacuum vessels is an external arrangement of the float and connecting rod in a so-called cage, illustrated in Fig. 6.

The cage is mounted on the vessel in which level is to be controlled, (Fig. 7), with the lower connection going into the liquid phase section and the upper tap in the vapor phase above the level. As in the gage glass, liquid level changes in the vessel are reproduced in the float cage.

The float, usually 6, 8, or 10 in. in diameter, rides half submerged on the level in the cage, and its movement is transmitted by rod and shaft through a stuffing box to a mechanical linkage and thence to the control valve, as in the internal ball float systems.

Design Considerations. A well-designed stuffing box has minimum frictional effects in order to avoid measurement errors and hunting or cycling of the control valve. Packing can be either synthetic, and thus require no lubrication, or of conventional materials, in which case provision for lubrication should be made. Where operating temperatures rise above 400 F, radiating fins on the stuffing box are provided for cooling. This practice avoids deterioration of the packing and also allows for lubrication that is not practical at temperatures in excess of 400 F.

Mechanical limitations of travel within the pressure cage housing are readily evident. In order to avoid excessively large housing castings, the travel is generally limited to distances not exceeding 1½ times float diameter. Since power available from the float cage mechanism is limited, valve sizes are generally 4 in. or smaller.

Relay Devices. Limitations both on available power and length of float travel that have been discussed above are overcome with the use of relay devices, either pneumatic or electric, and in some devices, hydraulic. Perhaps the most popular are pneumatic pilot relays, using as an operating medium air or noncorrosive gas, at a pressure usually not in excess of 100 lb. Pressure output of the relay is the standard 3 to 15 psi. Fig. 8 illustrates such a system on reflux separator level control.

Connection from the operating arm of the float to the nozzle or flapper of the relay is by mechanical linkage. This linkage is designed with suitable adjustments to give direct proportional response as the float rises and falls within the range or arc of its travel. Some models offered commercially have a proportional band adjustment variable between 10 per cent and 100 per cent of the float travel.

One major advantage of a pilot operated free float controller is the fact that the control valve need not be situated near the float mechanism as is the case with mechanically linked devices. Distances up to 600 ft are satisfactory. Another advantage is the power multiplication factor afforded by the pilot, with the attendant benefits of larger valves, higher degrees of accuracy, and reduction of hysteresis loops.

Hydraulic Transmission. A remote indicating system that is also popular (Fig. 9), is one that uses two matched metal bellows, connected by tubing, with the system filled completely by a relatively constant temperature-viscosity liquid. The float is linked to the transmitting bellows in such a way that the bellows is either expanded or compressed as this float rises and falls. Movement of the filling liquid compresses or expands the receiving bellows to which is attached a pointer, and if desired the flapper of a pneumatic pilot relay. A linkage adjustment at the receiving bellows compensates for temperature differences between transmitting and receiving bellows.

Limitations of Free Float Devices. Although free float mechanisms are perhaps the simplest of all liquid level detectors and controllers, their use is limited by the lack of power afforded by the float and its relatively small range of travel. With systems using pneumatic pilot relays, or having make-and-break electrical contacts, the power disadvantage is reduced.

All float mechanisms, however, are subject to errors due to float weight variations brought on by corrosion or fouling of the float by the process liquid. Where liquids with entrained solids are being level-controlled, such fouling is a major problem.

One of the great disadvantages of float devices in closed vessels is the difficulty of maintenance, either for periodic cleaning and inspection or repair of faulty operation. The use of the external cage float, with shut-off valves in the upper and lower connecting lines, alleviates this problem to some extent.

High pressure applications also pose a problem in choosing ball float devices. The float itself must be constructed to withstand the working pressures encountered, and the packing gland or bearing through which motion of the float is transmitted to external devices must also be carefully designed.

Float controllers of the direct mechanical linkage type pose the problem of valve location. For satisfactory operation, with maximum float power transferred to the valves, the latter must be placed close to the float lever. In large tanks, this sometimes involves complex and lengthy piping arrangements, and in other cases gravity flow from the tank cannot be utilized.

A last problem inherent in all float devices is erratic operation caused by surface turbulence of the liquid under measure-or control. Unless proper de-

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sign takes this into account, such turbulence can cause hunting or chattering of the valve.

Displacement-Float Mechanisms

It has been given in one estimate, that all of the various types of liquid level indicators and controllers used in today's refining industry, eighty per cent of them fall in the "float" classification. In this classification are grouped both those that have just been discussed — the free float devices — and this next type, displacement-float mechanisms. Further, authorities say that the use of the latter group far outstrips the first, and list many of the advantages of the displacement device. These will be discussed, but first, one point is necessary.

Strictly speaking "float" should not be a part of the name of the displacement mechanism, since actually, the primary element is simply a displacer of such size and weight that it will just sink in the liquid whose level is being measured or controlled. Through common usage, however, and partly as a result of the appearance of the device, the name float was attached and it has stuck.

Operation of Displacement Devices. The basic principle of operation of the displacement-principle instrument can be illustrated by a description of one of the earliest models. In this, a cylindrical displacer was suspended from a leaf spring in an external cage unit similar to those used with ball floats. The displacer was so weighted as to sink in the liquid, placing a small tension on the spring. As the liquid level rose in the cage, the weighted cylinder displaced more liquid, and thus appeared lighter by an amount equal to the weight of liquid displaced. This effective lightening resulted in an upward movement of the displacer by the action of the suspending spring. This movement was then picked up by a finger lever contacting the spring and transmitted through a stuffing box to the outside of the cage, where it was utilized to actuate the flapper of a pneumatic pilot relay system.

Two distinct advantages were immediately realized through a device of this type. One was that a much wider range of liquid level rise and fall could be handled, since maximum variation was determined only by the length of the displacer. (Naturally, as soon as the displacer becomes fully submerged, continued rise in liquid level has no effect on its effective weight.) The second advantage was a much greater accuracy than free float devices since a much smaller stuffing box could be employed.

Use of Torque Tubes. In the latter 1930's, a great advance was made in the design of displacement mechanisms, when its principle was combined with the use of the torque tube. Both stuffing box and suspending spring were eliminated, and with them went their inherent disadvantages and limitations. It is systems that make use of the displacer and torque tube or similar device that are prevalent in modern liquid level instrumentation.

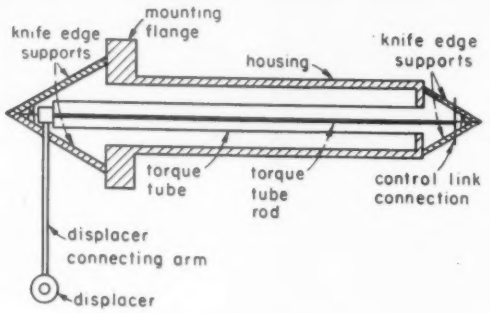

FIG. 10. Simplified section of torque tube arrangement.

Principle of the Torque Tube. A torque tube, in brief, is a hollow cylinder of metal held immovable at one end, and to whose other end is applied a twisting moment such as to produce a torsional stress along and between the walls of the tube. The angle of twist that can be produced by a given twisting moment is inversely proportional to the difference of the fourth powers of outside and inside diameters, and directly porportional to the active length of the tube.

Mathematically, this is:

$$\theta = \frac{L \times F}{(D^4 - d^4)G} \quad . \quad . \quad . \quad . \quad (1)$$

Where

θ = angle of twist
L = length of tube
F = twisting moment
D = Outside tube diameter
d = inside tube diameter
G = modulus of rigidity of tube

Thus a long tube will have a greater twist angle than a short tube, as will a tube with a very thin wall, provided the twisting moment is constant.

A simplified sketch of the torque tube as used in combination with a displacer is shown in Fig. 10. Twisting moment is the product of the "buoyant force of the displacer" (equal to the weight of liquid displaced), and the length of the displacer support rod.

Construction. The connection of the support rod to the movable end of the torque tube is one of extreme solidity, and of course the connection of the stationary end of the tube one of extreme rigidity. The stationary connection is usually to an outer tube or housing, whose angle of twist is negligible in comparison with that of the torque tube proper. One end of this housing is flanged and gasketed to the displacer cage, and the other end is fastened to the case of the pneumatic pilot arrangement. It can easily be seen that the assembly is pressure tight to the inside of the displacer cage and thus to the vessel whose liquid is under control.

In order to reduce frictional affects to the minimum, thus reducing hysteresis loops and to insure the highest possible accuracy, the movable end of the tube is supported in a knife edge bearing. Any effects of the displacer and support arm, other than the twisting movement, are also minimized by this bearing.

In order that the angular twist of the tube may be transmitted to the flapper of the pilot relay system, a solid rod is placed coaxially inside the torque tube, with one end fastened securely to the movable end of the torque tube, the other end resting in a knife edge bearing inside the relay case. Each fraction of a degree of torque tube twist is transmitted by this rod to the pilot relay mechanism. Thus the torque tube has its outer surface exposed to the process liquid and to process pressures — is completely a part of the environs of the process under control — while the inner surface of the tube is open to the outside atmosphere, or at least to the conditions of the pneumatic relay housing. Without packing glands or stuffing boxes, lubricators or radiating fins, the rise and fall of liquid level is sensed, measured, and controlled.

Installation. It is obvious from first principles that the specific gravity, or density of the liquid whose level is under control enters into the selection and installation of all displacement-float mechanisms. The displacer must be heavy enough to sink in the heaviest liquid in which it will be called upon to operate. As the general initial installation procedure is to manually rotate the torque tube housing until the dry weight of the displacer is supported by the torque tube, the tube must be sufficiently strong to endure the twist caused by this weight. When the displacer is completely supported, the housing is bolted into place. Additional stresses due to over-travel of the displacer must also be considered when arriving at allowable design stress values of the torque tube. Some current designs supplement the tube with a coil spring to aid the support and action of the displacer.

The length of the displacer determines the range over which the liquid level can be sensed, and therefore controlled. Generally, mounting of the whole mechanism is such that the desired point of control is reached when the displacer is halfway submerged.

Next part will be published soon.

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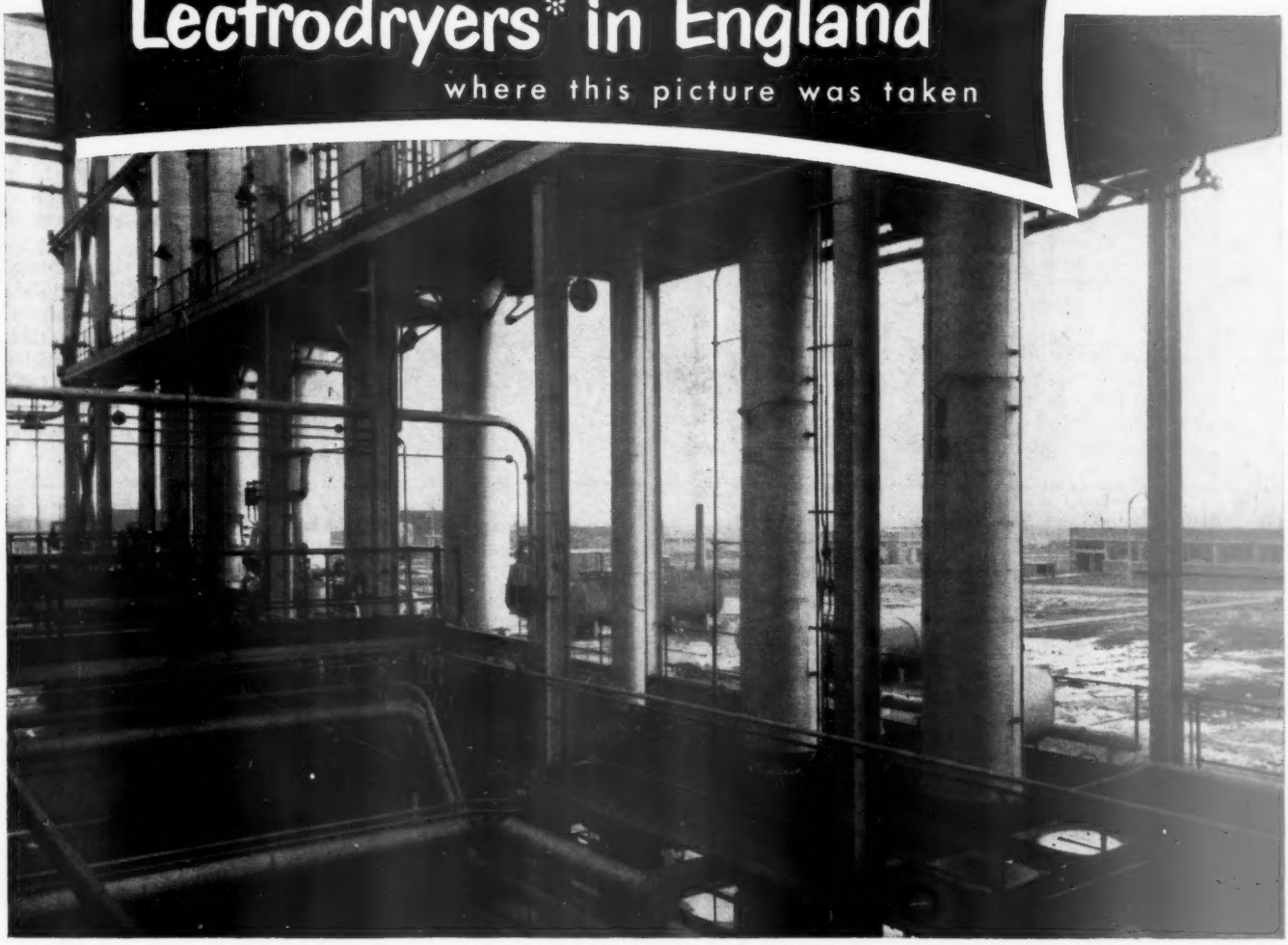

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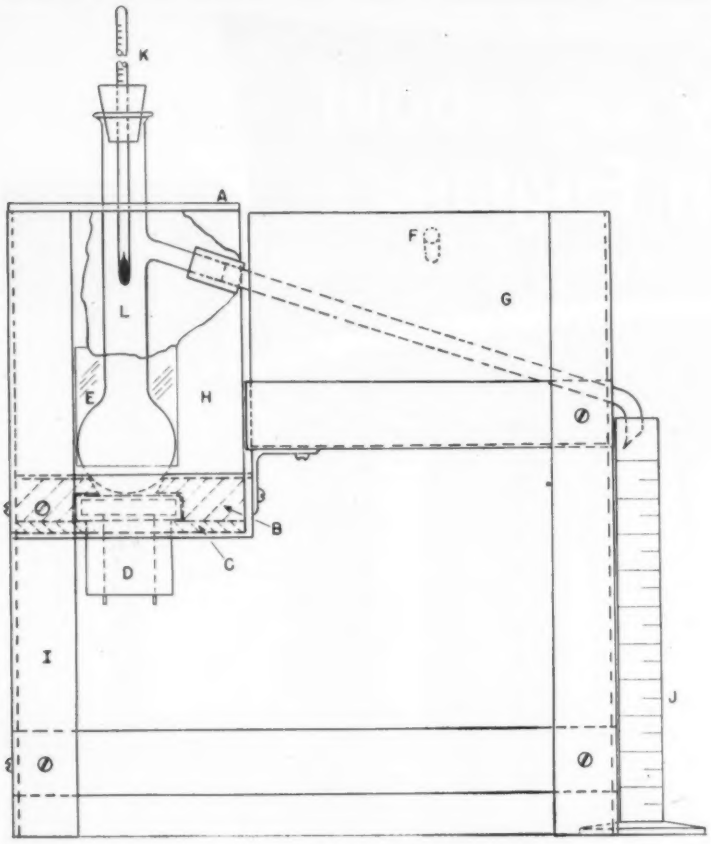

FIG. 1. Elevation drawing of 10-milliliter Modified ASTM distillation apparatus.

Modified ASTM Distillation for Ten Milliliter Samples

Careful attention to apparatus and method produces results comparable to the full-scale test

J. S. WIBERLEY and R. K. SIEGFRIEDT*

STANDARD method of test for distillation range, ASTM D 86-52[1,3] is a common test in petroleum laboratories. Its chief advantage is simplicity of apparatus and operation so that it can be performed in any laboratory. It is essentially a batch distillation on 100 ml of sample with temperature readings taken at the initial and final boiling points and at every 10 per cent cut in between. Although an arbitrary test, it is reproducible and hence widely recognized for specifying boiling range of mixtures such as gasoline and kerosine.

Occasionally, in the course of technical service or development work, comparable distillation data are required on samples smaller than 100 ml. For example, it might be necessary to check the distillation range on 30 ml of gasoline removed from the sediment bowl of an automobile. Or, as the result of a research program, 10-ml fractions of a solvent from an adsorption column might be submitted for analysis. To solve these and similar distillation problems, a modification must be devised to provide results comparable to the standard test with less sample. Levin, Morrison, and Reed[4] reported that their attempts to scale down the method were unsuccessful, the initial and final boiling points being most difficult to reproduce. Sommer and Wear[6] reported success with 3, 5 and 10-ml samples in glass micro-apparatus. Apparatus had first to be standardized empirically with known materials, however, and the rate of heating and procedure for reading the initial point adjusted to suit the type of sample. Some prior knowledge of the nature of the sample was thus necessary for best results. Initial and end points tended to be low on the wide-range materials.

An extreme reduction in the sample size from 100 ml to 0.0002 ml was reported by Wiberley, Siegfriedt, and Beneditti-Pichler, but the distillation range so obtained was only roughly that of ASTM and permitted only qualitative identifications. No doubt others, who have not published their findings, have attempted to scale down the apparatus in order to obtain a distillation range on a small sample.

The method described in this paper is a scaled-down version of ASTM D 86-52, which retains all test conditions of the standard method with the exception that a 10 ml sample is used. Results check the standard test except that 90 per cent points tend to be about 5 deg high and the final boiling points about 10 deg low.

Apparatus

(a) **Flask.** A standard 10-ml distillation flask with side arm cut to 20 mm length as shown in Fig. 1. Corning Catalog No. 4640.

(b) **Micro Thermometer.** A thermometer conforming to the following specifications should be used:

Range	90-500 F
Smallest graduations	5°
Larger graduations	10°
Numbered each	50°
Error	±2°
Diameter	3.5 mm approx.
Length of mercury bulb	7 mm approx.
Distance from top of bulb to first graduation	55 ± 5 mm
Thermometer length	170 mm approx.

The thermometer should be of the mercury-nitrogen gas type and be calibrated for total immersion. The amount of mercury in the bulb must be approximately one-tenth the amount present in the ASTM low distillation thermometer. This thermometer was custom made by Walter H. Kessler Company, 97 Reade Street, New York 13, New York.

(c) **Condenser.** The condenser shown in Fig. 1 is satisfactory. The condenser tube is constructed of ¼-in. outside diameter, 3/16-in. inside diameter copper tubing. It is set at an angle of 75 deg in the condenser jacket, subsequently described, so that approximately 4⅜ in. of the tube is in contact with the cooling medium. Approximately ½-in. of the tube should extend out of the cooling jacket at the upper end. The projecting lower portion of the condenser tube should be approximately ⅝-in. in length and be curved downward and slightly backward to insure contact with the wall of the receiving graduate. The lower end of the condenser tube should be cut off at an acute angle.

The condenser jacket is an open box

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EXCLUSIVE

4¼ by 2½ by 2½ in. made of thin copper sheet. It has a capacity of approximately 400 ml. The outside should be insulated with asbestos paper.

(d) **Shield.** The shield (Fig. 1) is constructed of thin sheet metal 4½ in. in height, 2½ in. in width, and 2½ in. in length. It contains a 1 by 1½ in. glass window so placed that the action in the flask may be observed. An asbestos cover for the top contains a hole just large enough to admit the neck of the flask. Asbestos insulation is provided for the bottom of the shield, having a hole 1 inch in diameter directly under the flask.

(e) **Stand.** A suitable miniature stand may be constructed of flat and corner strips of aluminum moulding ¾ in. wide such as is used to mount linoleum on kitchen counter tops. The legs and trays are made of the corner moulding; the legs are braced with the heavier flat moulding.

(f) **Heat Source.** A well shielded micro gas burner having a sensitive regulating valve or an electric cigar lighter* controlled by a variable transformer may be used.

(g) **Graduate.** A standard 10-ml cylinder graduated in tenths of a milliliter. The top is cut off approximately 10 mm above the 10-ml graduation so that the graduate can be inserted under the bottom tip of the condenser tube. Corning Catalog No. 3022.

Preparation of Apparatus

(a) Fill the condenser bath with cracked ice. Add enough water to cover the condenser tube. Temperature should be maintained between 32 and 40 F.

(b) Swab the condenser tube to remove any liquid remaining from the previous test. A pipe cleaner is satisfactory for this purpose.

(c) Place a 10-ml sample in the distillation flask by means of a volumetric pipet. None of the liquid should be permitted to flow into the side arm.

(d) Fit the thermometer, provided with a cork, tightly into the flask so that it will be in the middle of the neck and so that the lower end of the capillary tube is on a level with the inside of the bottom of the vapor outlet tube at its junction with the neck of the flask. The thermometer should be approximately at room temperature when placed in flask.

(e) Connect the charged flask to the condenser tube by means of chemically resistant rubber tubing. When the flask has been positioned, place the top asbestos cover over the shield.

(f) Place the graduated cylinder under the tip of the condenser tube. Cover the top of the graduate with a piece of blotting paper cut to fit the condenser tube tightly.

Procedure

(a) When everything is in readiness, apply heat at a uniform rate, so regulated that the first drop of condensate falls from the condenser in not less than 5 nor more than 10 min. When the first drop falls from the end of the condenser, record the reading of the distillation thermometer as the *initial boiling point.*

(b) Move the receiving cylinder so that the end of the condenser tube touches the side of the cylinder. Regulate the heat so that the rate of distillation is approximately 0.5 ml per minute. Record the reading of the distillation thermometer to the nearest degree when the level of distillate reaches each 1 ml mark on the graduate.

(c) The *end point* is the maximum temperature observed on the distillation thermometer and is usually reached after the bottom of the flask has become dry. If the bottom of the flask is not dry, record this fact.

(d) Record the total volume of distillate collected in the receiving graduate as the *recovery.*

(e) Pour the cooled residue from the distillation flask into the graduate and record the increase in volume as *residue.*

(f) Record the difference between 10 ml and the sum of the recovery and residue as *distillation loss.*

To express all volume figures in terms of per cent, multiply milliliters by 10.

Design Considerations

Before the present apparatus was constructed, the most readily available micro equipment was put together and tried. A 5- or 10-ml sample was placed in a flask of appropriate volume which was connected to a small water-cooled glass condenser. The sample was heated with a micro gas burner, temperatures were read on a standard size ASTM low distillation thermometer and the distillate collected in a small graduate. It was immediately noted that, as reported by Levin and others, the mid-boiling ranges were in fair agreement with ASTM values, but the initials were high and the end points very low. This was not particularly surprising since at the ends of the boiling range, temperature is changing rapidly with volume and a slight variation in conditions can produce a large difference in the temperature read.

It should be pointed out that scaling down this procedure is not a simple process of dividing all linear dimensions by ten. It may just as well be area or volume which must be reduced, and simultaneous reduction by ten times of length, area and volume is impossible[2]. In so arbitrary a procedure, judicious compromise is necessary. Also in the standard test there are certain "errors" inherent in the method and all of these "errors" must be retained in the micro method. For example, the thermometer is calibrated for total immersion but is used for partial immersion and no stem correction is ever made. This error amounts to 18 F at 500 F. Initial temperature is taken when the first drop falls from the condenser tip, but this reading is higher than the temperature at which that first drop boiled. Throughout the distillation there is this same lag in correspondence between the temperature and volume readings by the volume of hold-up in the condenser. End point is the highest temperature to which the thermometer rises, a point that depends on many factors such as the ratio of the volume of the sample to the volume of the flask,[5] the heat capacity of the thermometer bulb, heat losses by radiation and cracking of the product being distilled. It is evident that the procedure is expedient rather than correct and an understanding of the significant variables is necessary before the test can be scaled down satisfactorily.

The following considerations led to the present design of a 10-ml apparatus:

(a) Flask must contain one-tenth the volume. Surface area of the flask cannot be reduced in like proportion and consequently the reflux area in the neck and bulb is greater (by about three times) than it should be. Fortunately, results are not much affected by the

*Eagle Electric Manufacturing Company, Inc., Long Island City 1, New York. Catalog No. 444.

Engineer-Professor Joins Panel Staff

Dr. Brymer Williams, associate professor of the department of chemical and metallurgical engineering, University of Michigan, Ann Arbor, is a new member of Technical Forum Panel, a group that answers questions submitted by readers (See page C-18). He was graduated from Michigan with the Ph.D. degree in 1941, and spent the next six and one-half years with the M. W. Kellogg Company, New York, one of the world's foremost engineering firms.

There he worked in the general field of process design and development, in petroleum refining and allied processes, and in the production of oxygen. He returned to the University late in 1947, and since has been engaged in research in the fields of fluid dynamics, fractionation, and mass transfer, and especially in work in the phase equilibria and thermodynamic properties of hydrocarbon systems. During this period he also has had some consulting contacts with the petroleum and natural gas industries, thus keeping him in intimate "inside" touch with these industries and their practical scientific and engineering problems. Dr. Williams' high attainments in pure and applied science and his close liaison with industry fit him specially to answer questions in the fields mentioned, questions asked by those engaged directly in the industry's activities.

FIG. 2. View showing comparative size of micro distillation apparatus.

TABLE 1. Distillation ranges by ASTM and micro methods.

	Regular gasoline		Special gasoline		Aviation gasoline		Kerosine		Kerosine	
	ASTM F	Micro F	ASTM F	Micro F	ASTM F	Micro F	ASTM F	Micro F	ASTM F	Micro F
I.B.P.	101	98	96	95	106	110	334	335	345	346
10 per cent	146	135	126	124	155	146	364	365	381	378
20 per cent	166	162	146	143	170	170	380	383	394	391
30 per cent	189	186	164	162	188	185	394	397	406	401
40 per cent	211	209	184	182	200	200	410	412	412	410
50 per cent	233	231	206	205	213	213	426	428	421	418
60 per cent	251	254	230	230	222	222	442	445	428	426
70 per cent	269	274	258	262	230	232	458	460	436	435
80 per cent	290	298	294	301	238	240	474	479	444	443
90 per cent	319	331	341	351	253	263	496	500	457	457
End point	370	358	388	383	310	300	532	525	497	475
Recovery, per cent	98.0	94.0	97.5	95.0	98.5	95.0	....	96.0	98.5	97.0

	Rubber solvent				V M & P naphtha				Stoddard solvent		Paint retarder solvent		Insecticide base stock	
Per cent	ASTM F	Micro F	ASTM F	Micro F	ASTM F	Micro F	ASTM F	Micro F	ASTM F	Micro F	ASTM F	Micro F	ASTM F	Micro F
I.B.P.	112	109	152	153	200	202	249	251	315	318	364	363	371	375
10	149	146	159	160	207	206	261	262	325	323	381	381	385	387
20	164	162	160	161	209	208	266	267	327	326	387	386	390	393
30	175	174	162	163	210	210	269	270	329	328	392	390	393	396
40	185	185	164	165	212	211	273	274	333	330	397	395	398	401
50	192	191	165	166	214	213	276	277	335	332	403	402	403	405
60	200	200	167	167	215	215	279	280	338	335	411	408	409	412
70	208	211	170	170	218	217	281	283	342	339	419	417	417	420
80	216	215	173	173	220	219	286	287	346	343	428	427	424	427
90	225	228	180	180	226	226	291	293	355	352	441	442	441	449
End point	254	240	207	194	253	241	312	306	378	366	465	460	491	482
Recovery, per cent	....	95.0	99.5	97.0	99.0	97.0	99.0	97.5	98.5	97.5	98.5	97.0	99.0	96.0

slightly better fractionation. Because of the greater surface, however, radiation losses are higher, leading to low end points and a greater proportion of the sample adheres to the walls of the flask as a liquid film, leading to low end points and low recoveries. Experimental changes in the size of the neck did not seem to make much change in the results. A very short narrow neck would be theoretically desirable but would have practical disadvantages. A short side arm is necessary to reduce hold-up, a subject discussed in connection with the condenser.

(b) The thermometer bulb must have about one-tenth the heat capacity of the regular thermometer bulb, otherwise thermometer reading will lag and tend to be low, particularly at the end point. Consequently, a true micro ASTM distillation thermometer was designed and constructed. This thermometer is an essential feature of the apparatus.

(c) Dimensions of the condenser determine amount of hold-up, which in turn has particular influence on the initial boiling point.

Copper tubing was adopted rather than glass to keep heat conduction, wetting characteristics, and other factors as close as possible to the original condenser. Reasoning that the cross-sectional area of the liquid stream in a ¼-in. copper tube would be about one-half that in a ½-in. tube, length of the condenser was decreased about five times so that hold-up would be one-tenth the volume of hold-up in the standard test. Hanging drop on the tip is about the same size in either case and, as it is part of the hold-up at the initial point, a small compensating decrease was made in the length of the condenser. The condensing area comes out almost exactly one-tenth and the volume of the bath is not seriously out of proportion so that condensing conditions are reproduced very well. Insulation of the bath is necessary to reduce sweating and too rapid melting of the ice.

(d) Measurement of the dimensions of standard 100 and 10-ml graduates indicated that hold-up on the wall of the smaller graduate would be about twice as great as desired but would amount to less than one drop and so be negligible. A shorter graduate with less hold-up would be harder to read. Greater evaporation loss is to be expected and as a result the 90 per cent points have been slightly high (being actually 91 or 92 per cent points).

Results

Results obtained with this apparatus on representative products are given in Table 1. Excellent agreement is shown on initials and all points through 80 per cent. The 90 per cent points tend to be high on gasoline but on narrower range products, kerosine and solvents, agreement is still very good. End points definitely are low. A flat correction of 10 deg added to all end points would improve the correlation. All of these figures were reported as read and have not been corrected by any factors. They indicate what can be accomplished in scaling down an arbitrary test when significant variables are well understood.

Conclusions

This micro distillation test has been used where there was insufficient sample for the standard test. It might be considered where exceptional portability is required, i.e., in mobile laboratories. Aside from these features, however, it has no particular advantage. It is not faster than the standard test. It is not intended to replace D 86-52.

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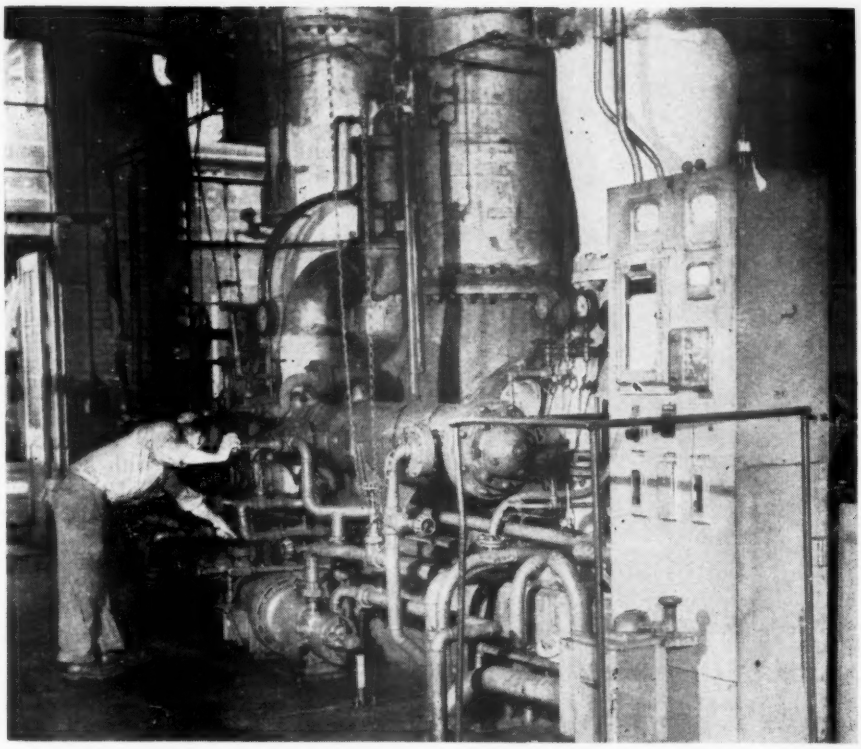
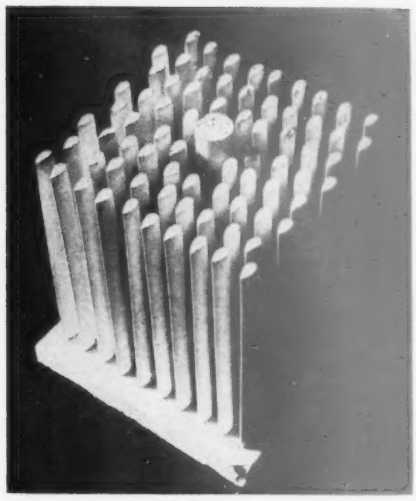
Underground Storage System Interests American Oilmen

A new development in underground oil storage, now in use in Sweden, is being considered by American oilmen. System is called "Edholm Container" and is said to be an economical, efficient method of storing crude oil and petroleum products underground. System employs water pressure to seal an underground storage cavern and prevent loss of stored oil. Cavern must be below the water table level. A report says the method would be useful for virtually all types of petroleum products storage with the possible exception of lube oils which may contain water-soluble additives.

XUM



USE OF catalyst heat to help run this turbine has meant a saving of about 80 kw for Sun Oil.



OXIDIZING catalytic unit is made up of two porcelain end plates and, between them, a spacer bar and 73 porcelain rods.

EUGENE J. HOUDRY, famed catalytic scientist and inventor, holds his oxidizing catalytic unit, Oxycat, which he developed several years ago.

Oxidizing Catalyst at Peak Performance

Platinum alloy operates at top efficiency and without loss of any qualities after 8500 hours

EUGENE B. BRIEN*

PLATINUM alloy catalysts installed to oxidize regenerator flue gases at a Sun Oil refinery were announced recently by E. J. Houdry as still operating at 100 per cent efficiency and without loss of any of their qualities after 12 months, or over 8500 hours, of continuous operation.

On June 5, 1952, a newly developed oxidation catalyst was installed to recover the heat of combustion in regenerator gases on one of Sun's large fixed-bed catalytic cracking units at Marcus Hook. According to Sun engineers, it operates at high efficiency by burning the waste carbon monoxide and hydrocarbons.

*Eastern editor.

A year later Sun was unable to detect any loss of operating efficiency. It now believes that the catalyst will last indefinitely and may need neither replacement nor regeneration.

These operating results are in striking contrast to the first oxidizing catalyst that lasted two months when first used in 1935. The economic results are similarly good; on an investment of $25,000 for the catalyst, Sun estimates that it will save $27,500 yearly on fuel alone.

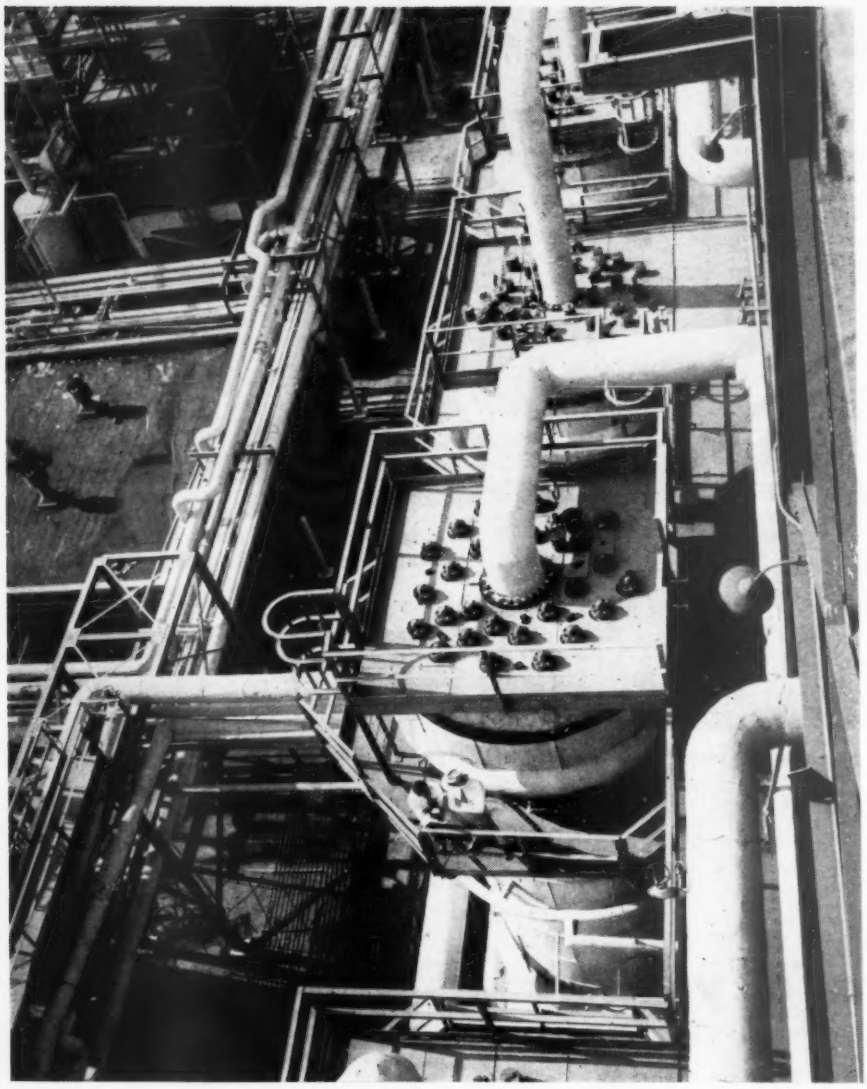
These encouraging results have moved Sun to plan to install the catalyst on the complete 12-case Houdry unit at Marcus Hook, where its present catalyst regenerates the gases from only six cases. The company reports plans to install similar catalysts on its stationary and moving-bed cracking units in its other refineries. It expects greater economies in the moving bed units, as the concentration of carbon monoxide in those flue gases is greater than in fixed bed units.

In a 5 per cent carbon monoxide flow and sub-cooling of the gases, Sun engineers estimate that heat recovery will produce 25,000,000 Btu per hour. With fuel evaluated at $2.75 per barrel with normal time efficiencies, savings would range between $85,000-90,000 per year for such a flow from one moving bed cracking unit, according to the engineer in charge of the program.

Alumina-Platinum Alloy

The new catalyst is an alumina and platinum alloy film 0.003 in. thick covering 73 ceramic sticks about 5.5 in. long. The sticks are staggered in rows between 3 in. square ceramic end plates. They are tear-drop shaped vanes which

EXCLUSIVE



TEST CASE run on a petroleum cat cracker at Marcus Hook refinery of Sun Oil. Oxycat converts waste gases to stream and electricity. One Oxycat bed installed in giant reactor case (nearest camera) is saving company $27,500 a year — more than enough to pay for itself. Engineers estimate that additional installations will save a total of $500,000 a year at this refinery alone.

permit gas flow with only a 0.05 in. drop of water pressure; the total area of the sticks takes up about one-half the total cross section of the unit. This brick, called "Oxycat," permits gas to flow up and around the sticks; in the process the gas comes in intimate contact with the entire surfaces of all the sticks. Oxidation takes place over those entire surfaces and the resulting combustion liberates heat.

It is said that the Oxycat will oxidize vapors and gases at temperatures well below their ignition point and in concentrations well below their explosive limits. For every Btu per cubic foot in the flow, the catalyst can raise the temperatures 55 F.

The catalyst can oxidize just about any combustible fluid, including all hydrocarbons, hydrogen, carbon monoxide, sulfur dioxide, and probably every other major source of gaseous pollution in the chemical industry, as well as carbon black, power plant soot, incinerator particles and similar solids.

Reportedly, it can operate over a wide range of inlet temperatures from the 500 F required for initial operation up to 1500 F, and in concentrations that vary from close to the explosive point to a few parts per million.

Once begun, it maintains combustion of room temperature gases, provided the concentration of combustible matter is such that the oxidation reaction raises the temperature of the gases to 500 F.

For complete combustion of contaminants difficult to oxidize, the catalyst must raise stream temperature at the outlet to about 1200 F. It varies, however, with the nature of the contaminants. In some cases complete elimination is obtained as low as 600 F. If traces of pollutants in the order of 100 ppm, can be permitted in the exhaust, the catalyst can operate at a low of about 900 F even with contaminants most resistant to oxidation.

Hence, the reaction may be self-sustaining, or the combustible flow must have a preheater.

The number of oxidizing units will vary with the concentration of contaminants in the exhaust streams. A rule of thumb postulated by the manufacturer provides one brick for every 5 cu ft per minute in high concentration and one brick for 100 cu ft per minute or more in trace concentration.

Commercial Uses

The first commercial use for the Oxycat was found as an attachment on the exhausts of fork lift trucks running indoors. Since then, 1500 units have been put into operation in over 200 industrial plants.

The first factory installation was designed to treat the fumes from ovens that baked metal coils with synthetic lacquers and enamels and drove off 24-30 drums of xylols, toluols, and other solvents per day. After 681 units were in operation, not a trace of odor could be detected, according to the Pennsylvania Health Department. The heat created by the oxidation of the fumes has been used to heat the ovens themselves with a resulting reduction of 90 per cent in the fuel formerly needed to run the ovens, it is reported. These savings come to about $2700 per month. Original costs of the catalytic units came to $13,000.

Sun Installation

The new catalysts at the Sun refinery replaced an older, pelleted element filling the major part of a reactor 10 feet in diameter and 30 ft in height. Laid in five layers of 500 units on ceramic spaces resting atop a stainless steel grating, the 2500 Oxycats now installed in the Sun Reactor occupy the top 15 inches of the vessel. Initial costs amounted to approximately $25,000. Replacement costs, if or when necessary, were originally estimated at $8000.

Sun estimates that with this investment it will save about $27,500 a year through a lower fuel bill on its present six case Oxycat installation. When the remaining six cases of the same catcracking unit are fitted with a similar oxidation reactor, it estimates that it will triple these fuel savings. Sun believes it will be able to cut its fuel costs by about $500,000 by installing similar reactors in its other refineries.

According to some, fuel savings for that part of the refinery industry where the catalyst can be applied may be as high as $8,000,000 a year.

The flue gases from the Marcus Hook refinery contain about 3 per cent carbon monoxide. Due to flow conditions the catalyst can oxidize the carbon monoxide to carbon dioxide for only two-thirds of the time. In the process it liberates 7,500,000 Btu per hour from the combustible flow. The conversion raises the gases from 775 F inlet temperature to 1075 F. Circulating salts in the heat exchangers lower the outlet temperature to about 825 F.

Of the recovered Btu, 80 per cent (6,000,000) is converted to high pressure steam in a salt boiler and the remaining 20 per cent produces about 80 kw of electricity via a gas turbine.

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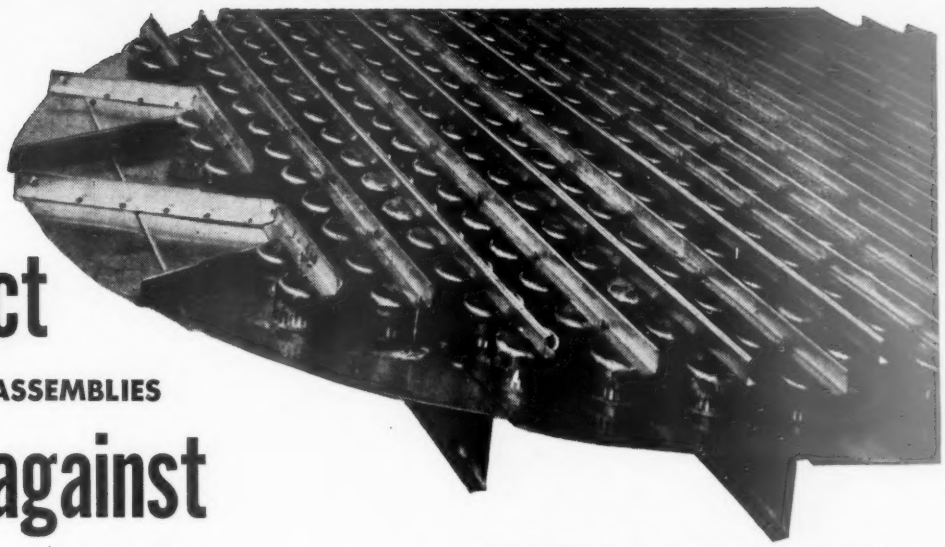
damage



Fritz W. Glitsch & Sons, Inc., Dallas, Texas, fabricated this lightweight bubble cap and tray assembly of corrosion-resisting Monel to withstand hydrochloric acid corrosion in the top section of a refinery fractionating tower. The strength and ductility of wrought Monel and Inconel lessen chances of breakage during installation. Trays which have been distorted by explosion can readily be straightened in the field.

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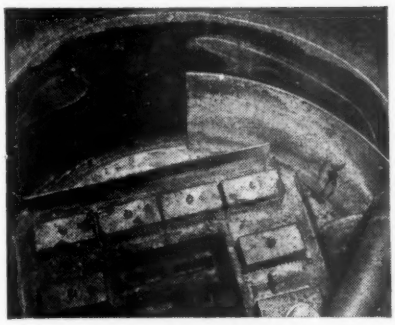
Their properties make it possible to use relatively thin-gauge metal for many applications. This means, of course, that you get lighter assemblies. Your cost for materials is lower...and installation and maintenance easier.

What governs your choice of Monel or Inconel? For the most part, it depends on service conditions.

Monel caps and trays are usually preferred where operating temperatures remain below 500°F. They are used to withstand the effects of dilute hydrochloric acid and wet sulfur types of corrosion in the upper sections of fractionating towers...and in the regeneration of spent caustic soda. Inconel, the nickel-chromium alloy, is used to resist high-temperature oxidation attack and naphthenic acids.

A wide range of designs is possible with Monel and Inconel. All are readily fabricated. They can be cut, formed, machined and welded by ordinary shop methods. They need no heat treatment after fabrication to develop maximum resistance to corrosion.

Keep Monel and Inconel in mind when you run into problems involving the use of metals in fractionation. And call on Inco's Technical Service for all the help you need. They have a world of information on hand, and are always glad to share it with you. The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.



Successful Experiment. Here you see the excellent condition of a Monel cap and tray assembly after extensive experimental service at the top of a caustic soda regenerator unit. Note how badly the adjacent steel wall has been corroded. In the same column, a steel tray with cast iron bubble caps ⬇ was located directly beneath the all-Monel top assembly. Corrosion made visible progress on the lower assembly, while the top tray and caps easily withstood attack.

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Prospects of Eastern Hemisphere Crudes

Q Little is found in our literature about the properties of Eastern Hemisphere crudes. Can you give compositions, distillations, and other characteristics of crudes from Borneo, Sumatra, etc.? How do these crudes qualify for sources of: 1. gasoline; 2. kerosine; 3. lubricants, and 4 asphalts?
E. J. C.

A Generally speaking it may be stated that the characteristics of the crude oils from Borneo, Sumatra, Java, and New Guinea vary widely, while even on these islands a number of types of crude is found and produced.

In Kalimantan, the Indonesian part of Borneo, there are produced mainly two types of crudes, a light non-waxy and a waxy crude. The former (A) contains appreciable quantities of aromatics (up to 39 per cent) and naphthenes (up to 35 per cent), the latter (B) has a wax content of about 8 per cent and serves for the manufacture of paraffin waxes at the Balikpapan refinery (Shell). Both types have a low sulfur content (<0.2 per cent by wt.). During 1951, Kalimantan produced about 2,900,000 bbl.

Northwest of Borneo is the small island of Tarakan. Here a heavy non-waxy crude oil (C) is produced, which on account of its low pour point and not too high viscosity is an excellent fuel oil and therefore it is marketed without requiring further refining. Its sulfur content is also low being 0.15 per cent by wt. Production during 1951 amounted to 2,555,000 bbl.

In Serawak, the western part of Borneo, the Miri crude (D) is produced, which is highly naphthenic, and may serve for the production of lubes. Production of Serawak during 1951 was 356,000 bbl.

In the northwest part of Borneo lies Brunei, which produced 37,000,000 bbl of oil, the so-called Seria crude, during 1951. There are two types of Seria crude, the waxy and non-waxy type. The latter (E) is a low gravity crude oil resembling that of Tarakan. The waxy type of Seria crude is a light crude which contains large quantities of gasoline and kerosine (See Table 2—K), the former being of very good quality.

Sumatra Crude Oils

The South Sumatra crude oils are for the most part waxy, although the lighter fractions (gasoline/kerosine range) contain appreciable amounts of aromatics. In Table 2 (G, H, I) some data are given for three South Sumatra crudes. The crude oil from the Talang Akar/Pendopo fields yields an excellent quality of wax with melting points up to 145 F. After Edeleanu treatment of the kerosine fraction, to remove the aromatics, good quality lighting kerosine is produced. Partly Edeleanu treating is also required to manufacture jet kerosine.

The gas oils of the South Sumatra crudes are of good quality and are used for the production of automotive diesels. The highly waxy crude residua have to be cracked to reduce its pour point, although by deep vacuum flashing of some of these residua less waxy gravity bottoms may be obtained that may serve for fuel manufacture without subsequent cracking (visbreaking).

The Djambi fields, lying north of the so-called South Sumatra fields, produce mainly light crude oils, with gravities of about 42-48 API, and which crude oils contain appreciable quantities of gasoline fractions.

Total production of crude oil from South Sumatra, including Djambi, was 45,300,000 bbl for 1951.

The Central Sumatra crude oils are very waxy. The Lirik crude (Table 2—L) for example cannot readily be pumped at ambient temperatures on account of its high pour point (95/100 F). The lower boiling fractions are also highly paraffinic, so that the gasoline is of extremely poor quality. The kerosine, however, is excellent in burning quality having a smoke point of 28 mm without any treatment. The gas oil fractions have exceptionally high diesel index and thus can be used for the production of high cetane automobile diesels, although on account of the high paraffinicity the pour point of these diesels is around 50 F. Good quality waxes can be produced from these Central Sumatra crude oils, but the extremely waxy residue is hard to process.

During 1952 the Minas field came into commercial production. Its crude oil (Table 2—M) is somewhat lighter than the Lirik oil, but still highly waxy.

Java Crude Oil

The main Java crude oil is the Kawengan crude, which is a waxy crude oil (Table 3—N). Production at Java during 1951 was 4,600,000 bbl.

New Guinea Crude Oil

The crude oils of New Guinea are entirely different from the other parts of the Archipelago. Main producer is the Klamono field, which produced during 1951 1,800,000 bbl of a heavy naphthenic type of crude oil, which can serve to manufacture lubes. Contrary to the crude oil from the other islands, which have all sulfur contents below 0.2 per cent by weight, Klamono crude contains sulfur up to 1.0 per cent by weight.

Asphalt

The residua of the naphthenic type crude oils may serve to manufacture asphalt. Further, on the island of Buton, south of Celebes, a bitumen is found that has been used for road asphalt. A small asphalt plant is located near Surabaia, on the island of Java.

Reference

1. The Science of Petroleum, Vol. II, 1938.
2. World Oil, July 15, 1952, page 220.

In. E. Ch. Campioni.

TABLE 1. Borneo crude oils.

Number	A	B	C	D	E
Type	Non-waxy	Waxy	Non-waxy	Naphthenic	Non-waxy
Area	Kalimantan		Tarakan	Miri	Seria
Crude oil					
Gravity, API	33	33	19	26.5	19
Pour point F	<32	...	<32	....	<32
Viscosity SSU (100 F)	34	38	103	39	114
Composition, per cent weight					
Gasoline	35	20	...	..18	2
Kerosine	29	38	...	8	..
Gas/Oil	16	6	...	24	29
Residue and loss	20	36	100	50	69

TABLE 2.

Number	G	H	I	K	L	M
Type	Waxy	Waxy	Waxy	Waxy	Waxy	Waxy
Fields	Talang Akar Pendopo	Radja Betun	Talang Djimar	Seria	Lirik	Minas
Area	South Sumatra			(Borneo)	Central Sumatra	
Crude oil						
Gravity, API	36.5	33.5	28	37	36	36
Pour point, F	80	65	85	55	95	80
Viscosity, SSU (100 F)	45.5	42	54	34	140	80
Sulfur, per cent weight	0.10	0.15	0.08	0.08	0.08	0.06
Components, per cent weight						
Gasoline, 380 EP	26	30	16	35	11	16
Kerosine, 540 EP	20	25	23	31	13	7
Gas oil, 650 EP	10	7	23	14	12	29
Par. dist., 880 EP	18	12	14	13	15	..
Residue and loss	26	26	24	7	49	.....
Gasoline, ON, MM	60	63	63	64	29	37
Kerosine, smoke pnt., mm	18	14	14	16	28	30
Gas oil, Diesel index	67	53	47	45	74	75
Par. dist., Pour point, F	105	100	110	110	115	.....
Residue, gravity, API	18	9.5	8	17	27	.....
Residue, M.P. F	135	135	155	100	132	.....

TABLE 3. + Java and New Guinea crude oils.

Number	N	O
Type	Waxy	Naphthenic
Area	Java	N. Guinea
Crude oil		
Gravity, API	37	19
Pour point, F	75	<0
Viscosity, SSU (100 F)	45	29
Composition, per cent weight		
Gasoline	13	5
Kerosine	12	11
Gas oil	45	29
Residue	30	55

The Author

Ingenieur Emile Ch. Campioni is superintendent of the Technical Service Division, N. V. Standard-Vacuum Petroleum Maatschappij, Sumatra, Indonesia. He is a graduate of the Delft (Holland) Technical Institute, and joined the company in 1934. Since that time he has had nearly continuous experience with refining, in Sumatra and in the U. S. except for three years detention in a Japanese prison camp during World War II.

EXCLUSIVE

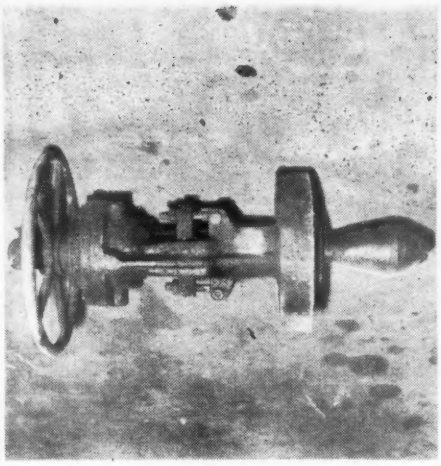

FIG. 1. Bottom of commercial valve employed earlier, that eliminated chatter but not coking-up troubles.

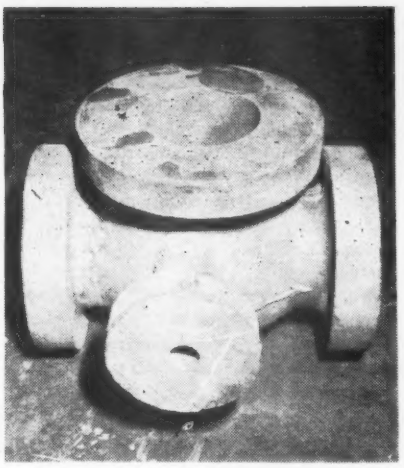

FIG. 2. Unmachined casting evolved finally by refinery engineering staff, for valve body.

Refinery Manufactures Special Quench Valve

Special design developed to eliminate chatter, coking-up, and other troubles in thermal cracking

HERSCHEL M. MARTIN*

THERE is no lack of manufacturers to supply the petroleum refining industry with the equipment and material needed in its plants. At The Eastern States Petroleum Company's Houston refinery, however, it became necessary to manufacture one of the industry's most commonly used items—a globe valve. The story of this diversion from the refinery's usual business follows.

Eastern States Petroleum Company has a conventional thermal cracker in which reduced crude and gas oil are heated in four separate coils before passing to a fractionation system. After leaving the furnace coils the hot oil stream is reduced in pressure and quenched with cold oil before it enters the fractionating towers. The reduction in pressure was originally accomplished by means of a conventional globe valve installed in the outlet of each furnace coil. These globe valves did not give satisfactory service because the chatter of the globe disc caused the valve to wear out quickly, and made control of the up stream pressure difficult. The valves also coked up quickly and this condition shortened the runs of the unit.

A valve manufacturer recommended a globe valve in which the disc was a solid steel plug which was an integral part of the rising stem of the valve. Fig. 1 shows this construction. Valves of this construction were installed. The disc chatter was eliminated and better service was obtained than with the original valves. Valves continued to coke up, however, and this alone made their operation unsatisfactory toward the end of the runs.

At first it had been the practice to quench the hot oil on the down stream side of the transfer valves. This practice gave poor control of the operation and as the hot oil passed through the transfer valves at cracking temperature it was thought to be a contributing factor to the coking of these valves. A high pressure quench system was installed and the cold quench stock was introduced into the hot oil on the high pressure side of the transfer valve. This gave better operation and reduced the coking in the transfer valve. This high pressure quench entered the furnace outlets through a specially fabricated piece of pipe installed immediately ahead of the transfer valve. This section of pipe was made of a short piece of 4-in. schedule 160 pipe with a 1½-in. schedule 160 nozzle welded into it at a 45 deg angle to the flow. Some erosion occurred at this point and when this was combined with an increase in the corrosion rate due to a change in charge stock the metal losses made it necessary to fabricate this section out of 4-6 Cr. ½ Mo. material. Later the continued increase in corrosion made it necessary to install the entire transfer line of the

FIG. 3. View of the finished, successful valve installed on the cracking furnace outlet.

*Chief engineer, Eastern States Petroleum Company, Inc., Houston, Texas.

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same material and the heaters were retubed with alloy tubes.

New transfer valves were also purchased with alloy bodies although their design remained the same. With these improvements the quenching operation was still not entirely satisfactory and it was decided to attempt to introduce the quenching stream directly into the side of the valve body. A 1½-in. nipple was welded at right angles into the valve body in such a manner that the oil from the quench system would enter the valve body slightly above the valve seat and strike the valve plug on a tangent. It was thought that the quenching at this point with the subsequent washing action on the plug would prevent coke formation in the transfer valves. Modified valves were installed and from an operating viewpoint gave excellent service. Control of furnace outlet pressures was easily maintained, and the coking in the valves was negligible. The construction of the valves with the welded nipples now proved unsatisfactory, however. As the valves were 4 in. and of a 900 lb rating, their bodies were very thick and the job of welding in the quench nipple was difficult. The casting and the nipple were both 4-6 Cr. alloy which is not the easiest of materials to weld. And, due to the great weight of the body of the valve when compared to the relatively thin walls of the nipple, the junction of the two was mechanically weak. With this in mind it was decided to obtain a valve in which the side entrance nozzle met the same specifications as the body of the valve. Several manufacturers were approached to see if they would be interested in making a valve of this kind. The order for the valves was to be for only five pieces for a very quick delivery and as a special casting was required no valve manufacturer could be found who could supply the valves by the time they would be needed.

The refinery engineering staff made drawings of the body of the special valve that was desired and a local pattern maker was given an order to build the necessary pattern and core boxes. This pattern was then sent to an electric alloy foundry and five castings were made of the valve body. A view of the unmachined casting is shown in Fig. 2. These castings were machined to standard ASA dimensions and then fitted with the bonnet and other mechanism of the standard quench valve. These valves have been in vis-breaking service for about three years and have given excellent service in every way. Their operation has been very satisfactory and the erosion and corrosion trouble is no longer serious. The coking problem has been eliminated and refinery operating personnel are completely satisfied with the installation. This is a good example of the varied type work performed by a refinery engineering staff. ★ ★ ★

☆ ☆ ☆

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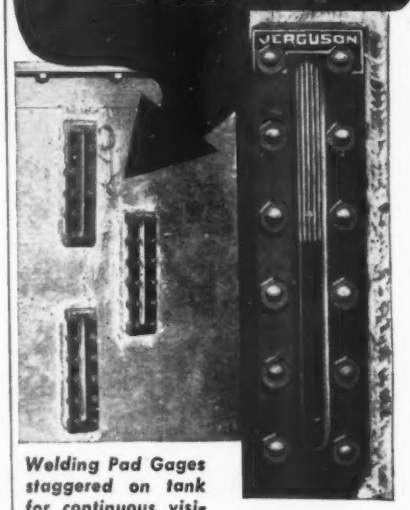

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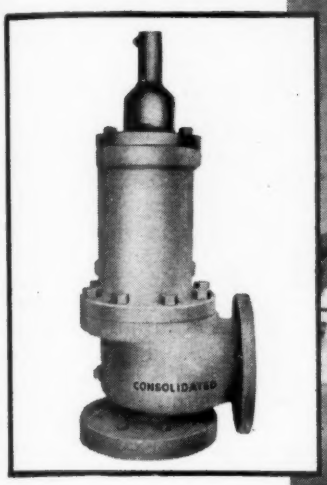

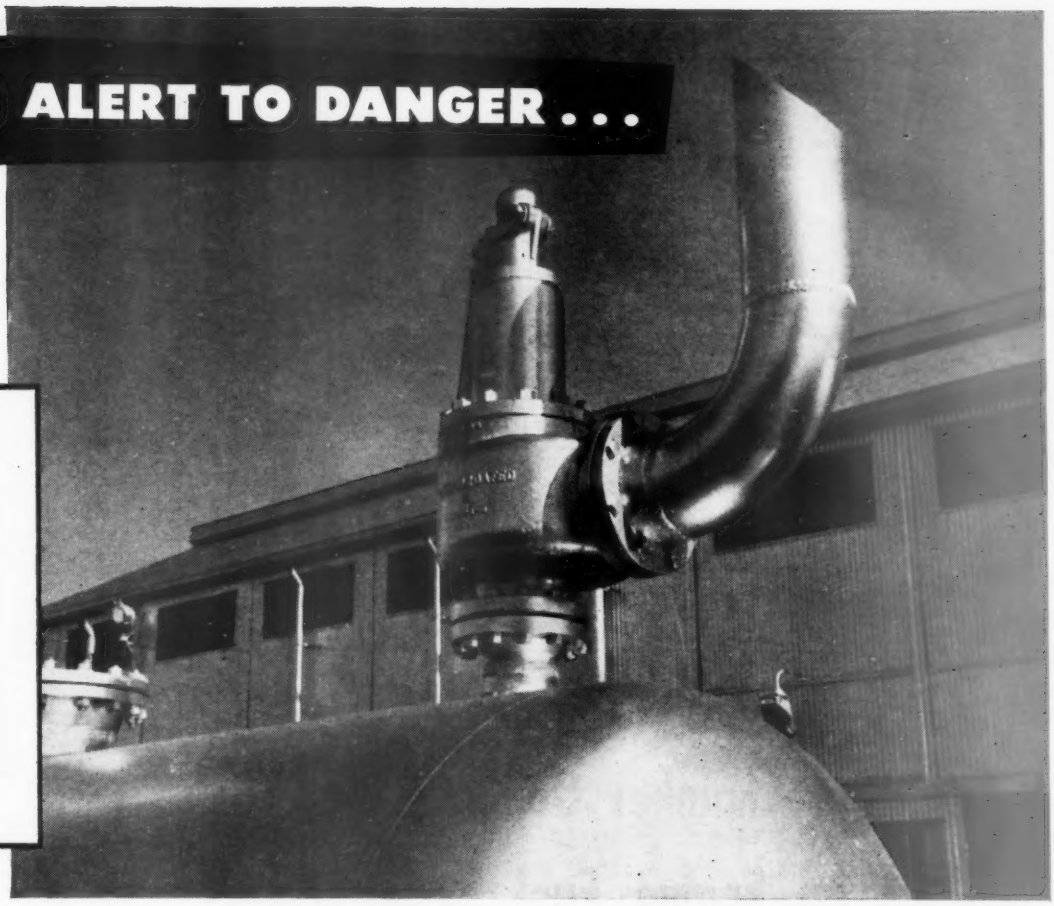

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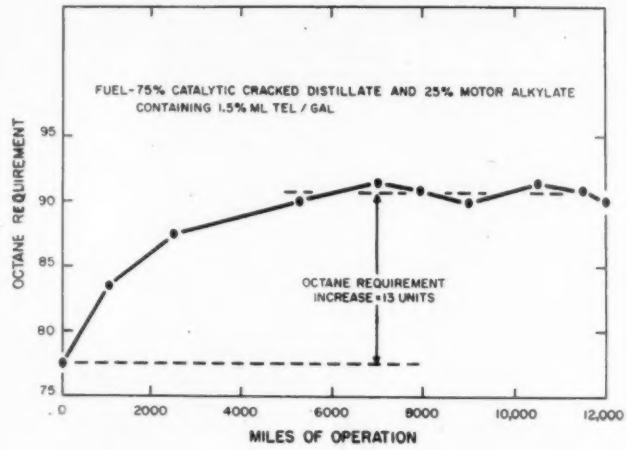

FIG. 1.—Effect of combustion chamber deposits on octane requirement of a 7.5 to 1 compression L-head engine operated in controlled medium duty road test.

Combustion Chamber Deposits and Their Effects on Engine Fuel Requirements†

Industry strives to increase efficiency of engines without requiring fuels of higher antiknock quality

J. J. MIKITA* and W. E. BETTONEY*

THE problem of increasing the efficiency of gasoline engines without requiring fuels of higher anti-knock quality is one that has challenged the ingenuity of fuel technologists and engine designers for many years. It is a well-known fact that the efficiency at which the heat energy of fuel can be converted into work in an Otto cycle engine is fundamentally dependent upon the compression ratio of the engine. Unfortunately, the limits to which compression ratios can be raised are governed by the occurrence of knock. This incompletely understood chemical phenomenon is important to the refiner because fuels substantially more knock resistant than those currently manufactured are inordinately expensive. It is important to the engine manufacturer because knock is one of the principal barriers to more efficient engines.

Broadly speaking, there are three aspects to the problem: One is concerned with the chemistry of the reactions which lead to knock in air-hydrocarbon mixtures, the second with the influence of engine design on knock, and the third with the role of combustion chamber deposits in increasing the tendency for fuels to knock. In this country, as well as abroad, the complicated chemistry of precombustion reactions is being investigated very diligently. Considerable progress has been made in understanding these reactions and it is likely that out of this work will come entirely new methods for combating the problem.

Engine manufacturers are attacking the problem from the standpoint of design. The engine designer recognizes that knock is the end result of certain oxidation processes in the unburned fuel-air mixture ahead of the flame front. Whether or not knock actually occurs is determined by the extent to which the reactions are able to progress. The course of these reactions is governed by the pressure and temperature of the unburned mixture as well as the time available. Engine manufacturers recognize that these three variables—pressure, temperature, and time—are controllable through engine design, and they are attacking the problem from this viewpoint. Considerable progress has already been made, and even greater advances may be anticipated.

Third aspect of the problem is concerned with the effect of combustion chamber deposits on the octane requirement of engines. Deposits that form in combustion chambers in two to four thousand miles of operation increase the octane requirement of engines by five to ten octane number units. A solution, or even a partial solution, of this aspect of the problem would permit a reduction in the octane number of fuels supplied for current engines, or conversely, it would permit an increase in compression ratios to take full advantage of currently produced fuels.

The problem of combustion chamber deposits has recently received a great deal of attention. It is, however, by no means a new one. Orelup and Lee[1] in 1925 stated, "Carbon in an engine is like scale in a boiler. It is one of the best heat insulators. The temperature of fuel burning in a heat-insulated cylinder soon rises above its critical temperature and thereupon breaks down in extraordinary manner. This is manifested by knocking or detonating." Livingstone and Gruse[2] in 1936 predicted, "It may be that soon we will realize the importance of carbon deposits in offering one of the main obstacles that stand between us and the advantages of high compression engines."

It is hardly necessary to say that, since engine designers have shown the way to really high compression ratio engines with attendant high thermal efficiencies, every octane number that can be saved by any means whatsoever assumes significance. The elimination or reduction of combustion chamber deposits offers one means of saving octane numbers and, therefore, it is a problem worthy of considerable effort. A great deal of work is being done on this problem in many laboratories. This paper will deal with the results of investigations carried out in the laboratories of the Du Pont Company to provide a better understanding of the problem.

Fig. 1 illustrates the combustion chamber deposit problem. These data show how the octane requirement of a particular car increased with miles of operation. The initial, clean engine requirement was 77.5 octane numbers expressed in terms of the primary reference fuels, isooctane and normal heptane. After six thousand miles of operation the requirement reached an equilibrium value of 90.5 and remained essentially constant thereafter to the end of the 12,000-mile test. At the conclusion of the test the combustion chamber deposits were removed and the octane requirement of the engine was again determined. It was essentially 77.5. Thus, the deposits increased the fuel requirement of the engine from 77.5 to 90.5, or 13 octane number units.

Photographs of the deposits as they appear on the piston top and on the

†Presented at the 41st annual meeting, Western Petroleum Refiners Association, San Antonio, Texas, March 23-25, 1953.

*Petroleum Laboratory, E. I. du Pont de Nemours & Company, Inc., Wilmington, Delaware.

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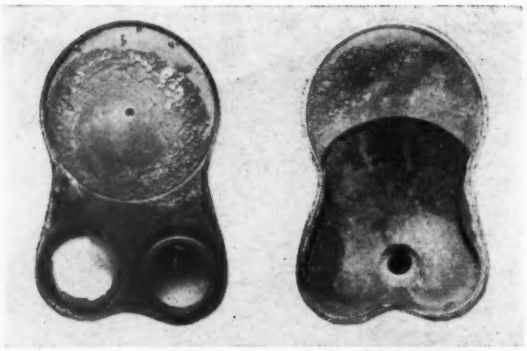


FIG. 2—Appearance of typical combustion chamber deposits after 12,000 miles of operation under controlled medium duty road test conditions.

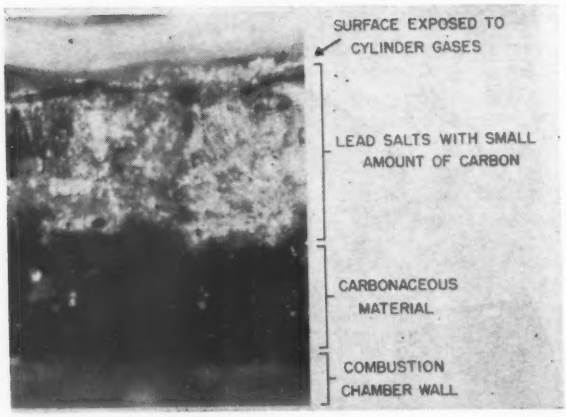

SURFACE EXPOSED TO CYLINDER GASES
LEAD SALTS WITH SMALL AMOUNT OF CARBON
CARBONACEOUS MATERIAL
COMBUSTION CHAMBER WALL

FIG. 3—Cross-section of piston top deposit accumulated with leaded fuel.

cylinder head are shown in Fig. 2, and a cross-section of the deposit is shown in Fig. 3. In this latter figure, it will be noted that the section of deposit adjacent to the combustion chamber wall, shown at the bottom of the photograph, is a dark, carbonaceous material originating primarily from the decomposition of the lubricating oil. The light gray material above the carbonaceous base layer consists largely of lead salts with some interspersed carbonaceous material.

The questions that first occur in any consideration of what might be done to eliminate deposits or to reduce their harm are, "How are the deposits formed?" and, "How do deposits increase octane requirements?" A great deal of work has been done to answer these questions and, although the exact chemical reactions taking place are not known in complete detail, the mechanisms involved are sufficiently understood to permit a rational approach to a solution of the problem.

How Deposits Are Formed

Examination of leaded fuel deposits in various stages of formation indicates that the first material to be laid down on the combuston chamber walls is a carbonaceous residue originating partially from unburned fuel fractions and mainly from decomposition of the lubricating oil, which enters the combustion chamber from the crankcase. This residue is believed to serve somewhat as a binder or adhesive for the lead salts resulting from the combustion of leaded fuel.

Formation of Carbonaceous residues. Livingstone and Gruse, [3,4,5] Bahlke, and co-workers,[6] and many others have published excellent papers on carbon formation from oil in engines. Although there may be some disagreements as to the exact mechanism by which oil decomposes in the combustion chamber, it is thought that the sequence of events is about as follows:

Some of the lubricating oil that flows out over the piston top on the upward stroke of the piston is sprayed into the combustion chamber when the piston reaches the top of its stroke. Of the droplets carried by the turbulent gases, the smaller ones are burned and expelled from the cylinder with the exhaust, while the larger droplets are partially coked by the flame and very hot gases and are subsequently deposited on the combustion chamber walls. It is not difficult to imagine that oil which has been subjected to such treatment undergoes (1) vaporization, (2) oxidation and cracking, and (3) subsequent polymerization of the oxidized and cracked products either in the gas phase or on the combustion chamber surfaces ultimately, to form asphaltic materials.

The amount of these carbonaceous residues formed in engines depends not only on the oil type used, but also on the conditions under which the engine is operated. Usually, about 15 weight per cent of the deposit is carbonaceous material; the other 85 per cent being lead salts, ash from lubricating oil additives, iron from engine wear, and silica from the air. On a volume basis, carbonaceous materials because of their lower density account for a much larger portion of the deposit.

Formation of Lead Salt Residues. The mechanism by which lead salt deposits are formed on combustion chamber walls has been explored by Newby and Dumont.[7] These investigators concluded that the only lead compound deposited on the walls under most conditions was lead oxide and that the solid lead oxide on the wall reacts with acidic gases in the combustion chamber—hydrogen halides* or sulfur oxides—to form the corresponding lead salts by gas-solid reactions. This is contrary to earlier beliefs that the simple lead salts —lead chloride, lead bromide, and lead sulfate—are formed in the combustion space by vapor phase reactions before being deposited on the walls.

During combustion of leaded fuel in an engine, tetraethyl lead is converted to lead oxide vapor which nucleates as solid PbO on the walls or on previously formed deposits. Thermodynamic calculation of the possible vapor state reactions of lead compounds that might be formed in an engine indicate that, under almost all conditions, all lead compounds are unstable in the high temperature exhaust gases except lead oxide.

These calculations were confirmed by a series of engine experiments in which gas-solid reactions of lead salts were isolated and studied. The possibility of vapor state reactions was eliminated by introducing the fuel additives into the combustion chamber at different times. For example, to study the formation of lead chloride by gas-solid reactions, the experiment consisted of operating an engine for 50 hours on two separate fuels: first, isooctane containing only tetraethyl lead and, second, isooctane containing one theory of chlorine as ethylene dichloride. These fuels were alternated every two minutes so that each fuel was used a total of 25 hours.

In this type of experiment lead chloride could be formed only by a reaction between solid lead oxide on the combustion chamber walls and the hydrogen halide in the gas, because at no time were the lead and halogen present together in the gas phase. For comparison, 25-hour tests were conducted in which identical quantities of tetraethyl lead and ethylene dichloride were both present in the same fuel. The weight and composition of the deposits formed in the first test, in which only gas-solid reactions could take place, were found to be the same as that in the second test in which both gas-solid and vapor-state reactions could take place.

Similar experiments conducted with fuels containing one-half theory of bromine as ethylene dibromide or 0.05 weight per cent sulfur as disulfide oil also showed that eliminating vapor state reactions did not affect the amount of deposit formed on either the cool or hot engine surfaces. Moreover, as shown in Figs. 4 and 5, the composition of deposits was not altered significantly by eliminating vapor state reactions.

As the result of thermodynamic calculations, work conducted in a laboratory apparatus and in engines operated as chemical reaction vessels, and through the use of radioactive tetraethyl lead as a scavenging tracer,[8] a basic knowledge of lead salt formation in an engine was gained. The sequence of these lead salt formation reactions in an engine is illustrated in general terms

*Sufficient ethylene dichloride and ethylene dibromide are included in tetraethyl lead mixtures so that theoretically there is 50 per cent excess halogen above that required to form lead halides.

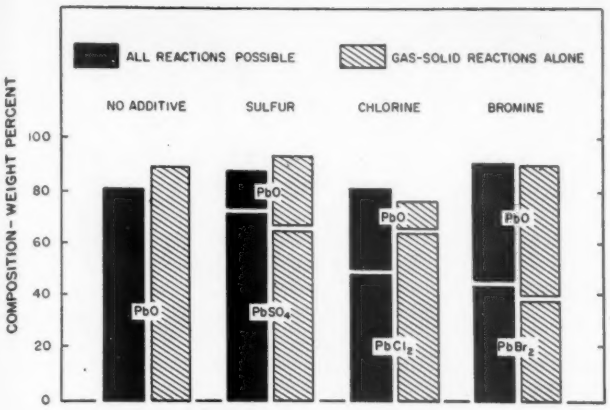


FIG. 4—Composition of deposits formed on "cool" combustion chamber surfaces with various fuel additives. In one type of experiment gas phase, solid phase, and gas-solid phase reactions were possible while in second type of experiment only gas-solid phase reactions were possible.

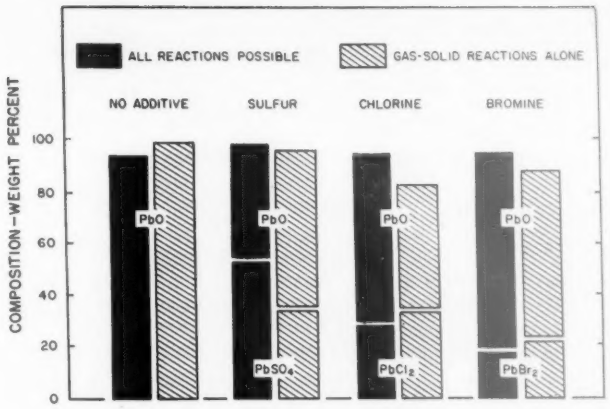


FIG. 5—Composition of combustion chamber deposits formed on exhaust valve surfaces in engine operated with various fuel additives. In one type of experiment gas phase, solid phase, and gas-solid phase reactions were possible while in second type of experiment only gas-solid phase reactions were possible.

in Fig. 6. The possible reactions are numerous and their final outcome depends upon the temperature of the surface.

Gaseous lead oxide, which is the final product of tetraethyl lead decomposition, does not react with either sulfur oxide or hydrogen halides in the gas phase with one exception. Under very cool combustion conditions near the surface of a cool wall or cool deposit, some lead halide might be condensed on the surface from the vapor phase. Except for this infrequent occurrence, only lead oxide condenses on the surface.

Solid lead oxide on the wall then reacts with hydrogen halides and sulfur oxides to produce solid lead halides and lead sulfate. At high surface temperatures, such as on an exhaust valve, lead sulfate predominates and the lead halides formed are vaporized. Under cool conditions lead sulfate is not formed and the lead halides that are formed remain in the deposit.

The deposit surface temperature increases with thickness and thereafter the lead halides and lead sulfate react with lead oxide to form lead oxyhalides and lead oxysulfates. The formation of lead oxysalts in engine deposits through solid-state reactions has been discussed at length by Lamb and Niebylski.[9] Seldom is any free lead oxide found in an engine deposit since both the acidic gases and the simple lead salts compete for it. Solid state substitution reactions can also occur in which one simple lead salt may replace another simple lead salt in a lead oxysalt. The acidic gases can also react with lead oxide in lead oxysalts, but to a lesser degree than with free lead oxide. The formation of these complex lead oxyhalides therefore seriously inhibits scavenging since they are considerably less volatile than the simple lead halides.

In any consideration of how deposits are formed, there are three phases to the probable mechanisms. Two of these, the formation of carbonaceous residues and the formation of lead salt residues, have been discussed. The third phase is concerned with the question of why these residues adhere to the combustion chamber walls.

Adhesion. The carbonaceous portion of the deposit is a very important factor in promoting adhesion. Baking of carbonaceous oil residues at moderately elevated temperatures leads to oxidation of the oil and reaction of the carboxyl groups in the oil residues with the metal oxide film on the combustion chamber walls. It has been found that the most adherent deposits are those that contain carbonaceous material with high percentages of oxygenated products but relatively little unchanged lubricating oil. Deposits formed at lower temperatures usually adhere less firmly since there is a film of relatively unoxidized and therefore unreacted oil next to the metal.

In addition to chemical bonding to the combustion chamber walls, the carbonaceous material may react with lead oxide to form organo-lead compounds. This effect has been duplicated by reacting the resins extracted from combustion chamber deposits with lead oxide to form hard, adherent solids which infrared data have shown to contain lead chemically bonded to the organic material.

The build-up of deposits also might be explained by present theories of adhesion which state that solids will adhere to each other provided:

1. Their surfaces touch over an appreciable area within distances comparable to the interatomic or intermolecular distances within the solids, and

2. The forces between the atoms or molecules of the contacting surfaces are sufficiently strong.

In other words, the strength of the bond is determined by the strength of the forces between the surfaces of the solids and by the extent of the areas which touch within molecular distances. In deposit formation, material is probably laid down by deposition of individual molecules and is therefore in sufficiently close contact with the surfaces of previous deposits to adhere to them.

Adhesion is also promoted if the very minute spaces between two solids are filled with a binder or glue. Considering the fact that the surfaces of hot deposits are sprayed almost continuously with lubricating oil, it is reasonable to suppose that this mechanism also plays an important part in binding lead salts into a solid form, especially under light or moderate duty engine operating conditions.

Lead salts can adhere to very hot surfaces such as exhaust valves, even though carbonaceous residues are not present. This is brought about either by reacting with the iron oxide on the surface of the valve to form a complex lead-iron salt or by the intermolecular forces previously mentioned.

How Deposit Equilibrium Is Attained

As has already been described, deposits undergo chemical and physical changes as they accumulate. Addition of lead salts to the carbonaceous binder results not only in the formation of a thicker deposit that insulates the combustible gases from the cool cylinder walls, but also in a deposit which is more active chemically. Lead salts, particularly lead oxide, accelerates the oxidation of carbonaceous material, and because of this action there is a continual decrease in the amount of carbonaceous material build-up after the lead salts start to deposit. As the accumulation of carbonaceous material decreases there is a corresponding decrease in the amount of binding material to trap and hold newly-deposited lead salts. The rate of oxidation of carbonaceous material at the gas-solid interface increases as the deposits become thicker and hotter, and ultimately, such material ceases to accumulate and the deposits are composed almost entirely of lead salts (primarily lead oxide). Once such a condition is reached the high deposit surface temperatures, together with the powerful, oxidation-accelerating effect of the lead salts, bring about a dynamic equilibrium between the rate at which carbonaceous residues deposit and the rate at which such residues are burned off.

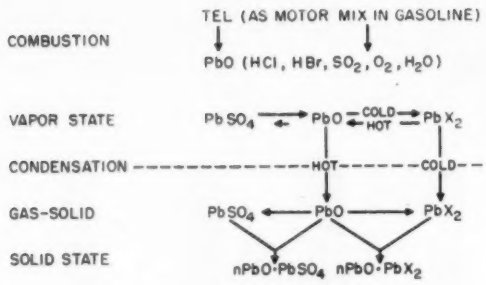
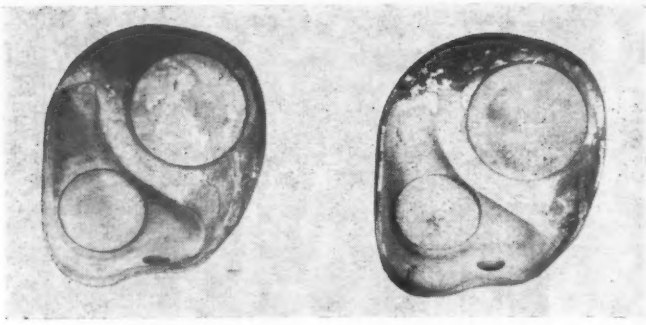


FIG. 6—Schematic portrayal of chemical reactions involved in formation of lead salt residues in combustion chamber of deposits.



Light duty operation. Heavy duty operation.

FIG. 7—Effect of operating conditions on appearance of combustion chamber deposits.

Establishment of this equilibrium is manifested by the attainment of a constant octane requirement.

In addition to chemical activity and thermal insulating effects, stresses set up in deposits by thermal and mechanical shocks contribute to equilibrium conditions. Such forces can cause the rupture of carbonaceous binder and promote the flaking and hence "mechanical scavenging" of comparatively large masses of deposit.

An insight to the physical phenomenon of flaking has been gained from relatively simple laboratory experiments. For example, the mechanism of lead salt deposition in an engine was simulated by condensing sublimed lead salts on a cooled steel surface placed in a furnace.

When lead oxide vapor was deposited on the metal surface, it formed thin, loosely combined layers that could be converted easily into lead chloride by exposure to dry hydrogen chloride at 212 F. The resulting deposit became microcrystalline and more adhesive and cohesive.

When brushed with a flame the top surface of the lead chloride deposit became sintered and glazed. Small fissures that had been observed in the microcrystalline deposit opened up because of surface shrinkage, and the deposit started to flake. When allowed to cool, the deposit flake would curl away from the metal surface. Touching the surface of the flake with a flame would return it to its original position. When the flame was removed, the flake would spring back as if on a hinge. This process could be repeated many times before the flake broke loose from the deposit. The flaking extended not to the base metal, but to a thin granular layer next to the metal.

When lead compounds were deposited on top of a hard resinous layer of carbonized oil which had been baked on the metal surface, flaking occurred down to the carbonaceous layer, but not down to the bare metal. If the lead compounds were formed on the surface of a less oxidized, oily layer, application of a flame fused the surface of the deposit, but the shrinking force developed could not overcome the adhesion of the sticky oil and the deposit would not flake.

Flaking, therefore, is a contributing factor causing deposits to reach an equilibrium weight after an initial build-up period. Flaking appears to be dependent upon a balance between the cohesive forces holding the deposits together and the adhesive forces holding the deposit to the walls. When cohesion exceeds the adhesive bonds the deposit may break away from the wall in the form of flakes. Apparently, flaking requires (a) high surface cohesion, (b) low adhesion, and (c) a deposit thick enough to have substantial temperature gradients. Shrinkage of surface layers by marked increase of cohesive forces will cause the deposit to pull away from the lower, less cohesive or adhesive layers. Sintering or partial fusing of lead salts can cause surface shrinkage. The greater the penetration of sintering, the greater the tendency of the deposit to yield a thicker flake. Shrinkage of the surface might be caused by (a) chemical reactions near the surface leading to volume contractions, (b) recrystallization on sintering at the surface with a resultant decrease in free space between crystals, and (c) differential thermal expansion due to differences in composition between surface and bottom layers.

One may speculate that under continuous medium-duty or heavy-duty engine operating conditions, where there are no violent fluctuations in deposit temperature for relatively long periods, deposits build up to a substantial thickness and the surface temperature reaches relatively high values. These conditions favor the formation of high melting point compounds which, upon cooling, contract and set up stresses higher than the cohesive strength of the deposit layer near the walls. Flaking close to the wall then occurs.

Under low-duty cyclic conditions, high gas temperatures and high surface temperatures seldom prevail for long periods and, consequently, conditions are ideal for the formation of lead halides. These halides glaze and sinter readily. Frequent violent temperature fluctuations such as occur in city driving could cause flake formation in a manner quite similar to that produced in the laboratory experiments with the cooled tube in the electric furnace.

Effect of Engine Operating Conditions. The physical and chemical nature, the appearance, the quantity of deposits, and their effect on performance are all readily affected by the manner in which the engine is operated. The temperature of the deposits, the temperature of the gases in the cylinder, and whether the engine is operated under constant duty or cyclic conditions play as important a part in deposit accumulation as do the fuel and oil. All these variables combine to make generalizations about deposits and their effects uncertain. Experimental results in this field are significant only for the particular set of variables used and should not be used to extrapolate to other conditions. For example, the physical appearance and harm of deposits formed under heavy-duty engine operating conditions are quite different from those formed in the same engine operated under very light duty conditions in city traffic. Fig. 7 illustrates the appearance of such deposits formed in two road tests each conducted with six vehicles operated in convoy. The deposit weights and equilibrium octane requirement increases with the same fuel and lubricant were as follows:

	Heavy-duty intercity operation	Light-duty city operation
Deposit weight, grams per cylinder	13	15
Octane requirement increase	6	14

Deposits laid down on the combustion chamber walls under steady operating conditions usually form a smooth, uniform surface which persists until flaking occurs. Fig. 8 shows photographs of a cylinder head at different operating periods. At 40 hours smooth deposits covered the entire cylinder head quite uniformly. Flaking, which began at approximately 70 hours, was quite advanced at 80 and 110 hours. On the other hand, as shown in Fig. 9, deposits formed under very light-duty, cyclic operating conditions present a "corn-flaky" appearance.

How Deposits Increase Octane Requirement

Basically, deposits increase the octane requirement of an engine either because they accelerate the reactions which lead to knock or they ignite the air-fuel mixture and thus lead to uncontrolled combustion. In high compression ratio engines — 7.5 to 1 or higher — these mechanisms are interrelated and are

24 REFINERS INCREASE DAILY THROUGHPUT WITH PETRECO DESALTING

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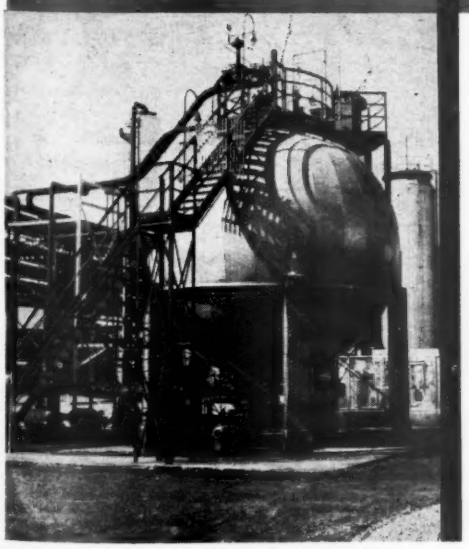
No.	TYPE OF CRUDE	GRAV. °API	BBLS. PER CAL. DAY		% INCREASE	NO. OF DAYS ON STREAM	
			BEFORE DESALTING	AFTER DESALTING		BEFORE DESALTING	AFTER DESALTING
1	OKLA. ASPHALT	16	950	1,900	100.0	1	75
2	TALCO, WINNSBORO	21	10,500	14,000	33.0	14	360
3	STEPHENS, ARK.	29	1,200	2,000	66.6	10	90
4	SO. LA. SWEET	38	11,000	13,000	18.2	100	125
5	NO. TEXAS SWEET	37	6,760	7,540	11.5	26	78
6	KANSAS SWEET	30+	3,360	3,820	13.7	37	125
7	MICHIGAN LIGHT	44	3,000	4,000	33.3	18	180
8	MIXED CRUDES	16-38	13,000	17,000	30.8	90	180
9	NO. TEXAS-OKLA.	40	8,000	10,000	25.0	33	145
10	GULF COAST	33	15,000	17,500	16.7	..	....
11	WEST TEXAS, SOUR	32	3,900	4,900	25.5	30	180
12	OKLAHOMA, SOUR	20	1,960	2,840	45.0	30	90
13	SHULER, ARK.	33	15,800	18,000	14.0	7	150
14	NEW MEXICO, SOUR	35	1,350	2,150	59.0	..	....
15	WEST TEXAS, SOUR	34	1,000	2,500	150.0	10	40
16	MICHIGAN	38	2,800	3,500	25.0	2	60
17	HASTINGS, SO. TEXAS	31	31,102	41,184	32.4	29	65
18	NO. TEXAS, OKLA.	40	4,000	4,940	23.5	90	180
19	MID CONTINENT	37	4,450	4,950	11.2	45	225
20	RANGER, NO. TEXAS	41	6,000	8,000	33.3	...	..
21	WEST BRANCH, MICH.	33	1,500	3,000	100.0	4	30
22	MICHIGAN	37	14,300	22,100	54.5	...	....
23	SANTA MARIA	14	2,200	2,700	22.7	60	365
24	WEST TEXAS, SOUR	33	1,850	2,750	48.5	90	365



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ELECTRIC PETROLEUM PROCESSING

CRUDE OILS: REMOVAL OF SALTS, SOLIDS, OTHER IMPURITIES; DEHYDRATING
DISTILLATES: ACID TREATING; CAUSTIC TREATING; DOCTOR TREATING
FUEL OILS: DESAPONIFICATION, ASH REMOVAL

PS 53-1

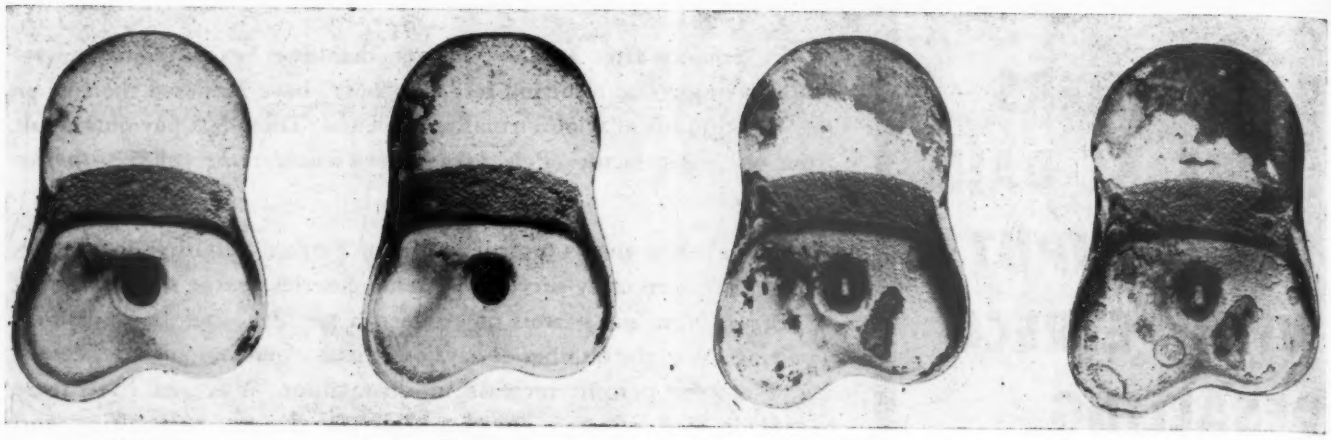

FIG. 8—Progressive accumulation of combustion chamber deposits in a laboratory engine operated under medium conditions on a fuel containing 3.0 ml TEL per gallon.

sometimes very difficult to distinguish.

Fig. 10 shows the sequence of events during a combustion cycle. The temperature and pressure of the charge is increased during its compression by the piston and certain oxidation reactions are started long before the spark is passed. After the spark has been passed, the flame front moves across the combustion chamber and the pressure and temperature of the unburned charge ahead of the flame front are further increased. The reactions that began early in the compression stroke continue at an ever-increasing rate. If the flame front moves completely across the combustion chamber before the reactions in the end gas go to completion, the result is a normal combustion. On the other hand if the reactions in the end gas go to completion before being consumed by the flame, this unburned gas autoignites and releases its energy almost instantaneously resulting in a pressure wave which flows back and forth in the combustion chamber. This high frequency wave sets some part of the engine structure in vibration and the result is a noise called **knock.**

It can be seen, therefore, that the occurrence of knock depends upon the rate and the path of hydrocarbon oxidation and the time available for these oxidation reactions to generate the chemical species which cause knock. For any particular fuel the rate of oxidation is dependent upon temperature and pressure, and engine operating conditions which raise the value of these variables increase the tendency for knock to occur. For example, increasing the compression ratio raises the compression temperature and pressure and thus increases knocking tendency; or increasing the jacket temperature retards the transfer of heat from the gases in the combustion chamber to the coolant, thus increasing the gas temperature and the knocking tendency.

With this general conception of combustion events in a cylinder and a few other facts, it is possible to arrive at some reasonable explanations of why deposits increase the octane requirement of an engine. These explanations are based on the hypothesis that the knocking harm of deposits is a result of four main deposit effects:

1. Volume.
2. Thermal insulation.
3. Surface ignition.
4. Catalysis.

Volume. The physical volume of deposits reduces the clearance space in a cylinder and thus increases the compression ratio. This effect has been investigated in several single cylinder engines. The engines were operated for a period of 70 hours during which the total knocking harm of the combustion chamber deposits was determined by measuring the octane requirement increase. At the conclusion of the test the volume of deposits was determined and its contribution to compression ratio was calculated. A deposit-free engine calibration of octane requirement versus compression ratio was used to determine the octane requirement increase caused by the volume of the deposits.

Typical results of such tests conducted with unleaded fuel and with a fuel containing 3.0 ml. tetraethyl lead per gallon are summarized in Fig. 11. These data, together with additional information from other similar experiments, have shown that from 10 to 40 per cent of deposit knocking harm is due to the physical volume of deposits.

Thermal Insulation. It has been suggested as early as 1925[1] that combustion chamber deposits have significant thermal insulating properties. Thermal conductivities measured in the authors' laboratory show the following average results for piston top deposits accumulated during 130 hours of operation of a passenger car engine. Deposits, especially those formed from unleaded fuel and which are essentially only carbonaceous material, are almost as poor heat conductors as asbestos.

	Thermal conductivity Btu/hr/sq ft/°F/ft
Leaded fuel deposits	0.217
Unleaded fuel deposits	0.138
Asbestos	0.135

That the surface temperature of deposits increases substantially with deposit thickness is indicated by changes in the chemical composition of succes-

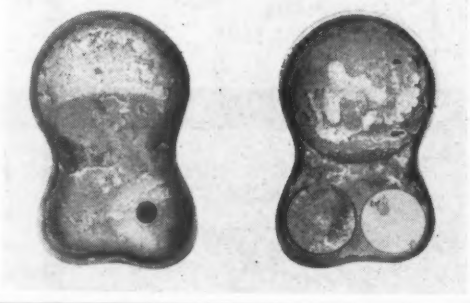

FIG. 9—Typical "corn-flaked" appearance of combustion chamber deposits formed under light duty cyclic operating conditions.

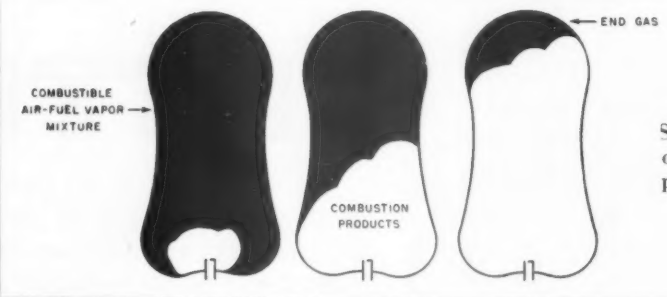

FIG. 10. Schematic diagram of combustion process.

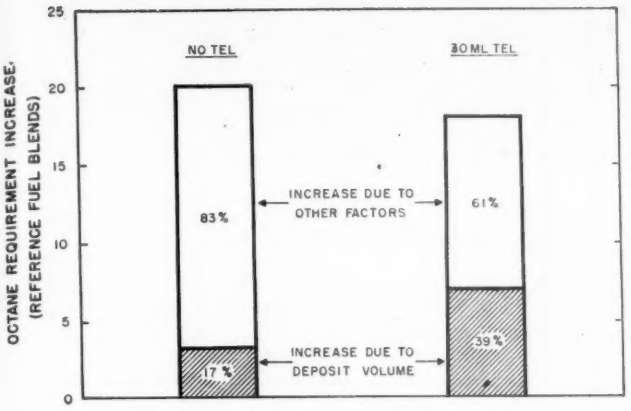

FIG. 11—Contribution of combustion chamber deposit volume to total deposit knocking harm in L-head single cylinder engine.

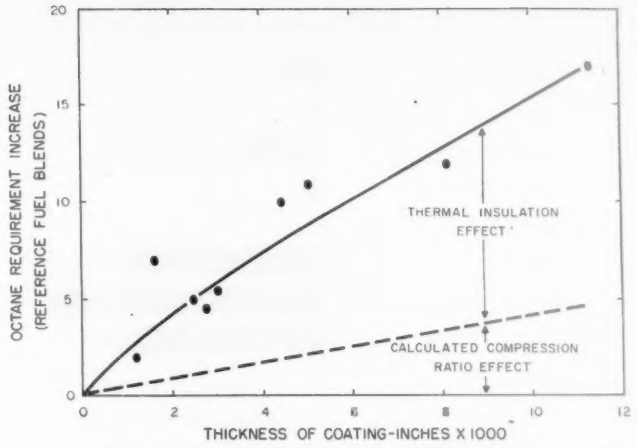
OCTANE REQUIREMENT INCREASE (REFERENCE FUEL BLENDS)
THERMAL INSULATION EFFECT
CALCULATED COMPRESSION RATIO EFFECT
THICKNESS OF COATING-INCHES X 1000

FIG. 12—Effect on octane requirement of a catalytically inert, low heat conductivity combustion chamber deposit consisting of coatings of "Teflon" tetrafluoroethylene resin.

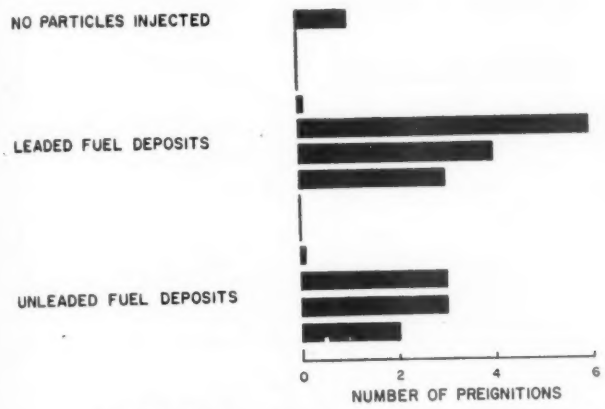

FIG. 13—Preignition induced by injection of dusts of combustion chamber deposits during acceleration of a 1949 passenger car with spark setting of 20 deg ATDC using 70 octane number primary reference fuel.

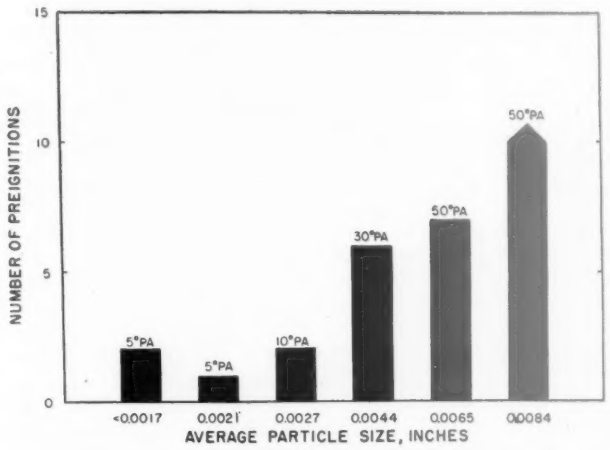

FIG. 14—Effect of preignition in a laboratory single cylinder engine of particle size of dusts of leaded fuel deposits. Tests conducted using CRC severity reference fuel 6-S-51.

sive deposit layers.[11] The facts are that deposits are good thermal insulators, they attain high surface temperatures, and they have a substantial heat capacity. They increase the gas temperatures and therefore octane requirement by:

1. Heating the charge drawn into the cylinder.
2. Reducing the rate of heat dissipation from the combustion gases.

The importance of thermal insulation was demonstrated when the octane requirement of a clean single cylinder engine was substantially increased by coating the cylinder head with various thicknesses of "Teflon"*, a non-catalytic material having very poor heat conductivity (0.145 Btu/hr/sq ft/°F/ft). As shown in Fig. 12, a coating of "Teflon" 0.006 inches thick increased the octane requirement of the engine ten units.

Surface Ignition. The surface of glowing deposits either attached to the wall or floating in the gas space can cause ignition of the charge. If this ignition occurs before the spark is passed, it is termed preignition and is equivalent to advancing the spark. Inflammation of the charge 10 degrees before the passage of the spark can increase octane requirement 5 to 10 units, just as would a corresponding increase in spark advance. Hot deposits may also ignite some part of the charge after passage of the spark and this is termed postignition. This phenomenon may also increase octane requirement for the reason that the combustion control which has been very carefully designed into the combustion chamber is virtually lost when inflammation occurs at one or more uncontrolled locations in the chamber. Withrow and Bowditch[10] have done excellent work on this harmful effect of deposits and have shown that particles of deposit floating through the combustion chamber act as uncontrolled ignition sources.

Confirmation of the important effect of deposit particles on preignition was obtained at the Du Pont Laboratories by injecting particles into the combustion chamber of a car on the road. The induction system of a 6-cylinder passenger car engine was modified so that a small quantity of relatively large deposit particles could be injected at the start of a wide-open throttle acceleration. Before deposit injection only an occasional preignition was observed during repeated accelerations from 10 to 60 miles per hour with a 70 octane number primary reference fuel and basic spark setting of 20 degrees after top dead center. As shown in Fig. 13, however, the injection of one gram of either leaded or unleaded fuel deposits caused a number of preignitions to occur during the acceleration. It is evident that both leaded and unleaded deposits can induce pre ignition when small particles enter the combustion space, but that the leaded fuel particles are slightly more harmful.

Similar experiments were conducted using a single cylinder laboratory engine with a spark advance of 10° BTC. It was found that increasing particle size increased the number of preignitions and also their severity as judged by the point in the cycle at which preignition occurred. The point in the cycle, in crank angle degrees, at which preignition occurred is shown at the top of each bar in Fig. 14. This effect is undoubtedly due to the higher heat capacity of the larger particles and their ability to exist through many cycles.

Of particular interest was the obser-

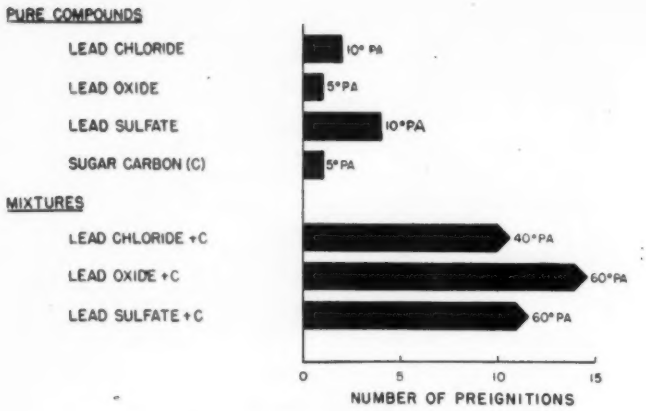

FIG. 15—Effect of 0.006 to 0.012 in. particles of lead compounds and carbon on preignition in a laboratory engine using CRC severity reference fuel 6-S-51.

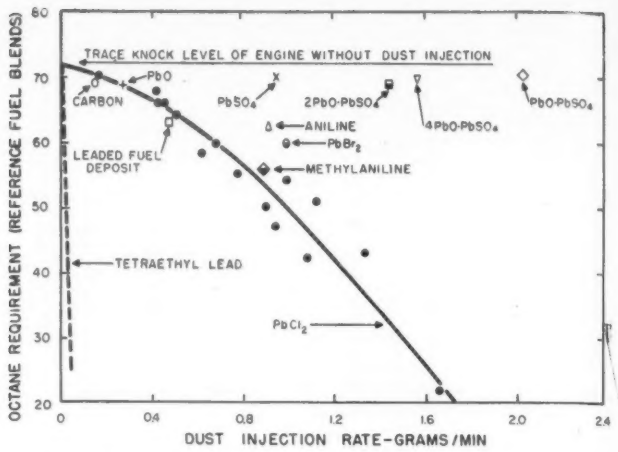

FIG. 16—Effect on knock of combusion chamber deposits and several of their individual constituents when introduced into combusion chamber as very finely divided particles.

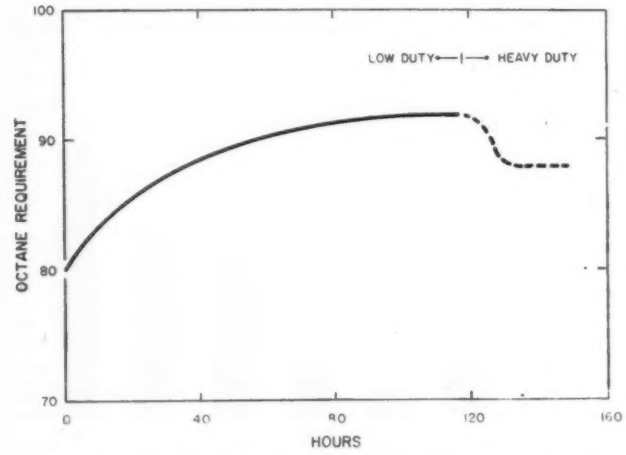

FIG. 17—Effect of heavy duty operation in reducing knocking harm of deposits accumulated in low-duty service with a commercial leaded fuel and commercial oil.

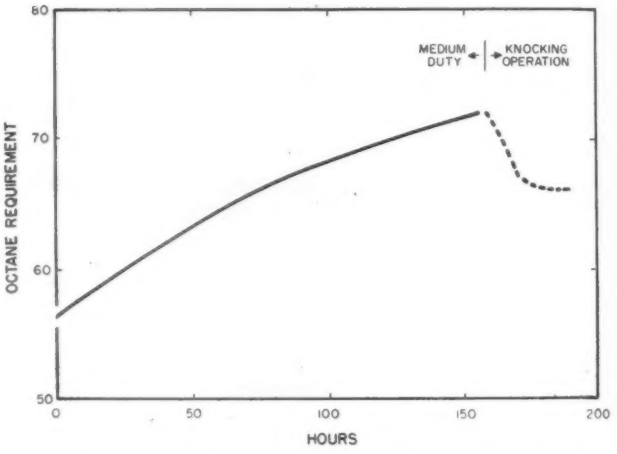

FIG. 18—Effect of knock on octane requirement of engine operated in medium duty service with a commercial leaded fuel and a commercial oil.

vation shown in Fig. 15 that neither pure lead compounds nor pure carbon cause appreciable preignition but that combinations of the two are very active. As pointed out by Withrow and Bowditch,[10] most lead salts catalyze the oxidation of carbon, not only causing it to ignite more readily, but accelerating the reaction rate so that higher surface temperatures result. This is a probable explanation for the preigniting tendencies of these mixtures. It is believed that unleaded fuel deposits are more harmful than pure carbon because they contain small amounts of metal contaminants from engine wear and possibly from oil additives. It has been found that small amounts of many salts promote the oxidation of carbon and cause preignition.

The preignition problem is accentuated at high compression ratios and the time will come, if it is not already here, when preignition will limit engine compression ratios.

Catalysis. It is reasonable to suggest that very hot deposits on combustion chamber walls can catalyze the reactions leading to knock; however, this is a very difficult theory to prove in an engine. An ideal technique for this experiment would be to coat the deposits with a very thin film of some non-catalytic substance, thus isolating the deposits from the gases without substantially interfering with heat transfer. Although many such materials have been tried none have been found which could withstand the high surface temperatures of the deposits. In a further attempt to isolate the contribution of catalysis to deposit knocking harm, experiments were conducted in which the effects of various dusts of lead salts and actual engine deposits were introduced into a clean combustion chamber in the form of finely divided particles of 28 to 58 microns particle size. It was reasoned that, if the materials injected were catalytic, the tendency to knock would increase.

As shown in Fig. 16, none of the materials increased the tendency for the engine to knock. On the contrary, lead chloride, lead bromide, and lead oxide acted as anti-knock agents, although rather poor ones compared to tetraethyl lead.

Although this experiment does not disprove the catalysis theory, it does indicate that relatively large quantities of lead salts in a very finely divided state and with a large surface area do not catalyze the knock reactions when introduced directly into the reacting gases. It is possible, however, that the reacting gases forced into the interstices of the very hot deposits on the combustion chamber walls during the compression stroke of a normal engine cycle may undergo considerable oxidation. The peroxides thus formed and released from the deposits during the subsequent intake stroke may have a pronounced effect on precombustion reactions.

Octane Requirement Increase

As was mentioned earlier, the physical and chemical character of combustion chamber deposits is largely determined by their temperature, and this in turn is a function of engine operating conditions. If sufficiently large changes are made in deposit physical properties, the deposit knocking harm may be changed and therefore changes in engine operating conditions can alter the knocking harm of deposits.

Generally speaking, high temperature operating conditions which produce dense, smooth deposits, or operating conditions which promote very extensive deposit flaking, result in less octane requirement increase. The effect of a short period of high temperature, high

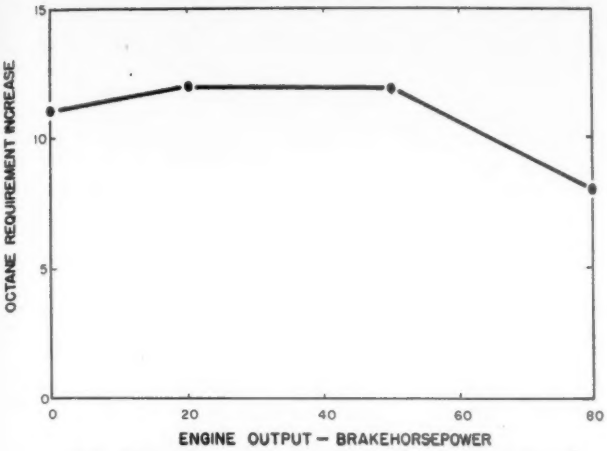

FIG. 19—Effect of operating conditions on octane requirement increase in laboratory engine operated on commercial leaded fuel and commercial oil.

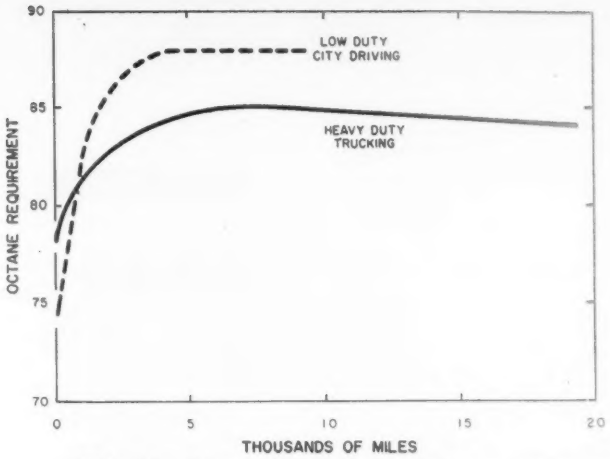

FIG. 20—Effect of operating conditions on octane requirement and octane requirement increase in road test vehicles using commercial leaded fuel and commercial oil.

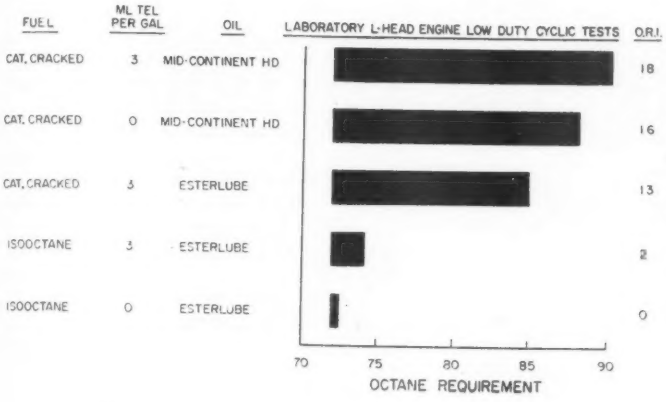

FIG. 21—Effect of various fuels and lubricants on deposit knocking harm in engine operated in laboratory under low-duty cyclic test conditions. Data shown are averages of three or more tests on each variable.

power operation in reducing the knocking harm of deposits which had been accumulated under low-temperature, low-duty cyclic conditions is illustrated in Fig. 17. This effect of high power operation on engines normally engaged in low-duty service has been observed frequently and is sometimes used to reduce the octane requirement of engines in service. Similar effects have been observed following relatively short periods of operation under knocking conditions as shown in Fig. 18. The violent pressure waves resulting from knock undoubtedly produce extensive deposit flaking, and the thick, lightly adhering deposits produced during normal, low-duty operation are particularly susceptible to this action.

The effect of operating conditions can also be seen in Fig. 19 in which is shown the knocking harm of deposits accumulated with a particular fuel and lubricant during several different tests. The operating conditions of the various cyclic tests were selected to simulate either (a) very light, (b) light, (c) medium, or (d) very heavy-duty operation. It will be noted that the knocking harm of the deposits, which was measured after the 130-hour tests, was least after operation under the very heavy-duty conditions. This occurred in spite of the fact that the through-put of deposit forming material was much greater than for all other types of operation.

Similar results have been observed in the course of road tests as shown in Fig. 20. In these tests the same engines were operated in the same vehicles except that in one case trailers containing seven tons of gravel were towed at high speed over semi-mountainous terrain, thus duplicating heavy-duty inter-city trucking. In the other case the same engines and vehicles were operated in the downtown streets of Los Angeles without the trailer, thus simulating light delivery truck service. Note the more rapid increase to the higher equilibrium octane requirement caused by the deposits accumulated in the low-duty service. The decrease in octane requirement observed toward the end of the heavy-duty trucking test was caused by extensive deposit flaking and is not unusual for engines operated in such service.

Even more striking effects can be produced by changes in the fuel and lubricant. It has been observed, however, that very considerable alterations in both fuels and lubricants are generally required before large changes in deposit knocking harm are to be noted. Apparently, even a small amount of carbonaceous material will serve as a binder for other materials and, therefore, only small effects will be observed unless the amount of binding material has been greatly reduced. This observation is supported by the laboratory test data in Fig. 21 showing the knocking harm of deposits formed by fuel and oil combinations in which one or the other material is virtually free of deposit-forming constituents. It will be noted that by far the greatest effect is achieved when using a fuel and an oil having a minimum tendency to form carbonaceous materials.

Some of the laboratory test results shown in the previous figure have been checked by means of road tests using the same combinations of fuels and lubricants. These tests were conducted by laboratory personnel operating six vehicles in convoy under mild duty conditions. As shown in Fig. 22 the laboratory results were virtually duplicated in the road test, thus indicating a good degree of correlation between the road and laboratory test procedures.

Inasmuch as light-duty operation has been found to produce the most harmful type of combustion chamber deposits, several light-duty road tests have been conducted using as a test course some of the more congested streets of downtown Philadelphia. One such test was conducted to measure the knocking harm effects of two fuels having markedly different tendencies to form low temperature engine varnish and sludge. Fuel A was a volatile blend of 50 per cent alkylate and 50 per cent catalytically cracked distillate, while Fuel B was a rather heavy fuel consisting of approximately 90 per cent of another catalytically cracked distillate with some polymer and a little alkylate. Fuels A and B differed also in their performance in the FL-2 test, the latter fuel forming substantially more varnish and sludge deposits than Fuel A. There was a very slight tendency toward more deposit knocking harm with Fuel B than with Fuel A as shown in Table 1. More important, however, was the observation that the deposits formed by Fuel B

TABLE 1. Effect of two different fuels on octane requirement increase. Light duty passenger car service.

ML TEL in fuel	Car make	Octane requirement increase	
		Fuel A	Fuel B
0	X	10	10
3.0	X	9	8
1.5	Y	11	14
3.0	Y	12	13

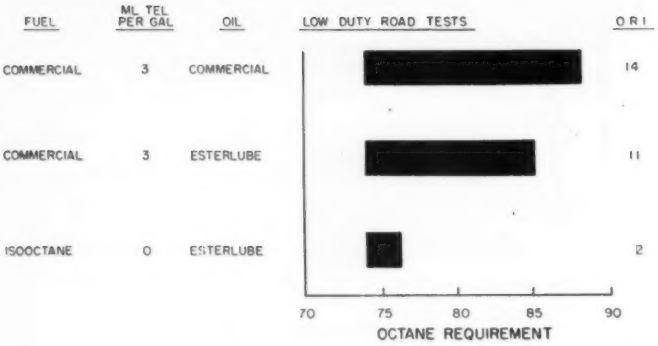

FIG. 22—Effect of various fuels and lubricants on deposit knocking harm in vehicles operated in light duty service road test. Data shown are averages of two vehicles each.

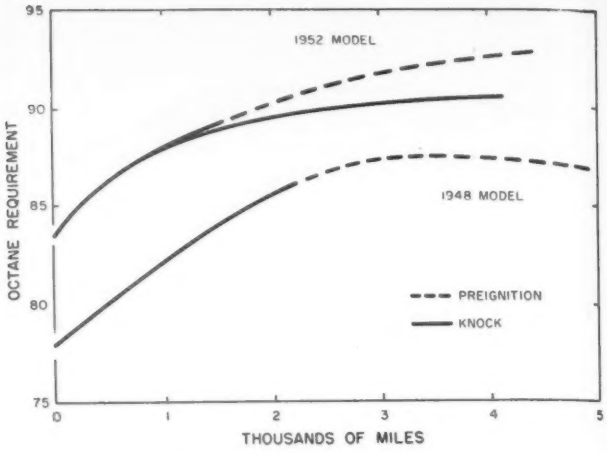

FIG. 23—Difference in fuel anti-knock quality requirements, particularly for overcoming preignition, between a 1948 and a 1952 model of same make passenger car. Only essential difference between the engines was an increase of compression ratio.

tended to cause appreciably more preignition and it was necessary in the case of one combination of fuel and cars to use substantially higher octane quality reference fuels to overcome preignition than was required to overcome knock. This is shown in Table 2. As the average motorist would not appreciate the subtle distinction between knock and preignition, and also since the violent, loud noises resulting from preignition are more noteworthy than the knocking noise, it is obvious that more "knocking" complaints would arise from the users of Fuel B.

The foregoing test was conducted using 1948 and 1950 model automobiles. A more recent test involved the operation of a 1952 version of the older of the vehicles for 4500 miles on a fuel similar to Fuel B. The newer car was equipped with an engine of a somewhat higher compression ratio and other minor modifications. As shown in Fig. 23, not only was the clean engine octane requirement higher but after only 1000 miles of operation this car was preignition limited; that is, a higher octane number fuel was required to prevent preignition or wild ping than was needed to suppress knock. Thus, for this car at least, preignition is a more important problem than knock.

Still more evidence of the importance of preignition was obtained from the results of other light-duty road tests conducted using four V-8 valve-in-head engines of 9:1 compression ratio. In these tests the fuel required to overcome preignition was approximately two octane number units higher than that required to suppress knock. In many instances preignition, or postignition, occurred to such an extent that the engine continued to operate with the ignition turned off. This we have called run-on; it is a manifestation of ignition of the charge by a hot surface within the combustion chamber. It is interesting to note that no such surface-ignition occurred when the engine was in a deposit-free condition.

It is evident from these more recent road tests that the already formidable problem of preventing knock is to be further compounded by the problem of preventing surface-ignition.

Summary

Considerable progress has been made in understanding the mechanisms by which deposits accumulate and increase octane requirement. The presence of carbonaceous material which acts as a binder for lead salt residues appears to be the largest single factor accounting for deposit accumulation. During the combustion process tetraethyl lead is converted into lead oxide which is deposited as such on the combustion chamber walls. Once deposited, the lead oxide undergoes complex chemical reactions with the acidic gases in the combustion chamber to form the variety of lead compounds found in deposits. These reactions are directly controlled by the temperature of the combustion chamber gases, and the temperature of the deposit surface, which increases with increasing deposit thickness.

When a sufficient deposit thickness has been reached flaking begins, which results in a state of deposit equilibrium. Flaking is believed to be due to thermal stresses induced by cyclic melting and cooling of the top layer of the deposits so that the cohesive forces of the top layer greatly exceed the adhesive or cohesive forces in the portion of the deposit nearer to the engine surfaces.

Deposits increase engine octane requirements by increasing the temperature of the last portion of the charge to burn and also, particularly in the cases of higher compression ratios, by causing ignition of the charge by hot surfaces.

Results of laboratory and road tests demonstrate that large reductions in deposit knocking harm can be effected by the use of fuel and lubricant combinations which leave only small amounts of organic residues in the combustion chamber. If normally available fuels are used, changes in the type of lubricant do not result in a pronounced reduction in octane requirement; however, significant improvements are effected.

TABLE 2. Effect of two different fuels on "critical" requirement increase. Light duty passenger car service.

ML TEL in fuel	Car make	"Critical" requirement increase Fuel A	Fuel B
0	X	10(k)	10(k)
3.0	X	10(kp)	9(p)
1.5	Y	11(k)	18(p)
3.0	Y	12(k)	13(kp)

k — Due to knock only.
p — Due to preignition only.

Acknowledgment

The information contained in this paper summarizes various phases of investigations conducted by a large group of individuals and the writers take this opportunity to express their appreciation to them. The writers are particularly indebted to Drs. G. H. Patterson, W. E. Newby, H. P. Landerl, and J. L. Hyde of Jackson Laboratory; to Dr. B. M. Sturgis, Messrs L. F. Dumont, A. O. Melby, P. H. Richard, and W. E. Morris of the Petroleum Laboratory.

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Fundamentals of Petrochemicals Syntheses for Refining Technologist

Because the engineer, chemist, technologist, and operator in petroleum refining and petrochemical industries are universally intent in the methods and processes for synthesizing the increasing number of chemicals from petroleum natural gas hydrocarbons *The Refining and Petrochemical Edition* is instituting this month a series of articles that will present in condensed and concise form fundamental reactions, operations, raw material sources, and products obtained therefrom. These products make up the list of intermediates in this industry that is growing so fast it has been said, "Only a daily telegraph service can keep us up-to-date on these developments."

These articles will be written by a number of different authors, selecting as far as practicable those best fitted by education, training and recent experience to discuss the methods of synthesis of each major product in turn. These articles will be short though of varying length as befits the relative importance of the different products. Primary chemicals will be discussed first in this series; probably later we shall go further and discuss some of the finished products made from these primary materials that use hydrocarbons as charge stocks.

You are invited to follow this series from month to month, and you will find the answers to innumerable questions regarding this newest field of expansion for the refining and the chemical industries, which collaborate for advancement.

Synthesis of Petrochemicals—I

ETHYLENE PRODUCTION METHODS

ARCH L. FOSTER

Of all the organic chemical intermediates made directly from petroleum and natural gas hydrocarbons ethylene is by far the most important. As of 1950 production of various chemicals including ethyl alcohol, ethylene glycol, etc., amounted to nearly 1½ billion pounds, based on ethylene with the output rising steadily each year. Of all plastics now being produced polyethylene is the largest in volume, and several companies are designing or constructing additional facilities to go on stream within the next year or two. In fact, the rush into ethylene and polyethylene production has been so rapid that at least one combine has withdrawn its plans to enter the field, due to prospective or possible overproduction within the next few years.

A number of methods exist for ethylene manufacture, and most of them are based on pyrolytic operations. Dehydrogenation by means of catalysts is practicable, technically speaking, but the economics has not appealed to producers as much as has thermal methods. One of the earliest commercial operations for producing ethylene was that employed by Phillips Petroleum Company to crack ethane-propane mixtures — largely propane — by purely thermal means, to obtain ethylene for the synthesis of neohexane as an aviation gasoline component.

The net reaction of converting ethane or propane to ethylene-propylene is simple;

$$\underset{\text{Ethane}}{H_3C{-}CH_3} + (\text{Heat}) \rightarrow \underset{\text{Ethylene}}{H_2C{=}CH_2} + H_2 \qquad (1)$$

$$\underset{\text{Propane}}{H_3C{-}CH_2{-}CH_3} + (\text{Heat}) \rightarrow \underset{\text{Ethylene}}{H_2C{=}CH_2} + \underset{\text{Methane}}{CH_4} \qquad (2)$$

At temperatures of the order of 600-700 C (1112-1292 F), the amount of heat required to promote the dehydrogenation in (1) is 31,200 calories per gram-mol, (56,160 Btu per pound) whereas for (2), splitting off a molecule of methane (which in practice probably is converted largely to carbon and hydrogen), requires only about half as much reaction heat, 16,500 calories per gram-mol (29,700 Btu per pound) (Science of Petroleum, Vol. V).

Basic investigation of this reaction in 1935 showed that by heating ethane to 843 C (1550 F), with a residence time under this temperature of a fraction of a second converts 75 per cent of the ethane to the olefin. Because of the less severe conditions required for cracking propane, that method has been used industrially with considerable success. The rising cost of propane as raw material, because of its increased use as liquefied petroleum gas (LPG), has militated against its use for ethylene.

Ethane dehydrogenation is said to be at maximum yield at about 1800 F, (nearly 1000 C), at which 83 per cent of the ethane is converted to ethylene. In cracking heavy oils to form light olefins, it is found that a maximum of butenes is obtained at about 650 C (1202 F), of propylene at about 700 C (1292 F), and ethylene at about 800 C (1472 F); this process is no longer employed directly. Some ethylene is or may be recovered from cracked refinery gases but in general does not offer any satisfactory inducement for large scale recovery.

More recently a new process, the TPC (Thermofor Pyrolytic Cracking) method, has been introduced for the production of various olefins including ethylene. (*Petroleum Engineer*, August, 1948, p. 43). This process employs two vessels, the heater and the reactor. The heating medium is a mass of small, spherical non-catalytic, refractory pebbles, ranging from 0.2-inch to 0.4-inch diameter, high in density and in specific heat, made to offer high resistance to abrasion or attrition in use. These pebbles are heated by direct combustion of gas in an air stream within the bed in the heater to the required temperature then are dropped in a continuous stream into the reactor where the stream of hydrocarbons to be cracked is met and where the dehydrogenation-cracking takes place. Technologists for Socony-Vacuum Oil Company that developed the process say that externally fired heaters have been studied also, but that they are more expensive and less efficient. This type of reactor system is said to transfer heat at very high rates, of the order of 15,000 Btu per degree Fahrenheit per cubic foot of pebbles per hour.

Charging ethane to the reactor the

conversion to ethylene was 49 per cent at 1525 F and 2.3 sec contact time, with yield only 0.7 per cent of acetylene. At 1770 F, and 0.12 sec contact time 56 per cent of ethylene was formed, but also nearly 4 per cent of acetylene. Operating on propane, once-through showed 37.5 per cent ethylene. Recycle on mixed ethane-propane with considerable amounts of propylene showed a final yield of 62 per cent ethylene. In all cases the reaction stream is quenched instantly upon exit from the reactor, to stop undesirable side reactions.

This process may be used successfully, it is claimed, to crack a wide variety of hydrocarbons, from ethane to reduced crudes. The ratios of pebbles to feed (by weight) may range from 10 to 20. Preheat temperature of the pebbles may be from 1400 to 1800 F. and contact times from 0.1 sec to 2.5 secs. This contact time is controlled by regulating the space rate of vapors through the pebble bed. Charge may or may not be preheated before entering the reactor. Carbon deposited on the pebbles becomes an advantage rather than a detriment, since in burning it off the pebbles are heated with less consumption of outside fuel.

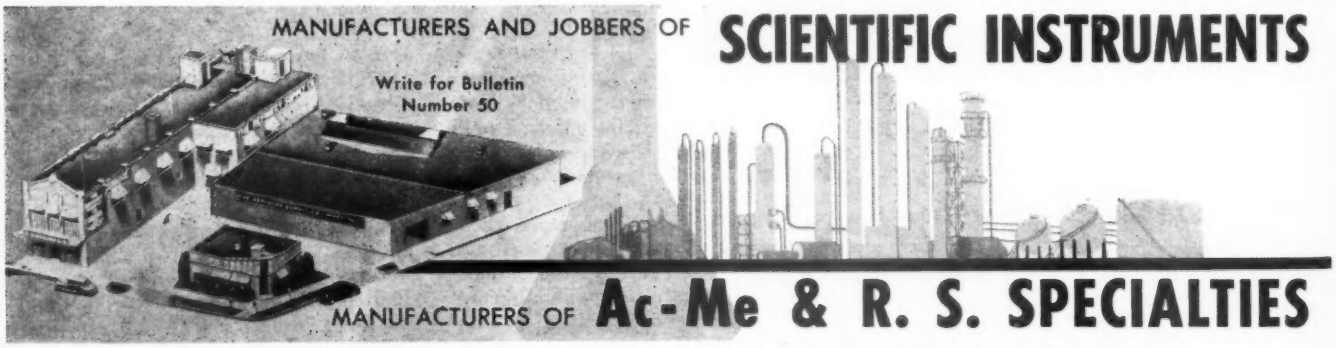
Operating on liquid feed stocks this process, in the range of 1500-1550 F temperatures has shown an ethylene production of from 12 per cent on light catalytic cycle stock to about 29 per cent on Michigan crudes, according to data published in 1948. Considerable amounts of propylene, butylenes, and butadiene are formed also with from 36 to 55 per cent of hexanes and heavier. Good yields of aromatics along with ethylene can be produced also by extending contact time, a subject that will be taken up in a later article.

The cost of producing ethylene by any of the recognized processes is dependent in large measure on the degree of purity required by the processes in which the product is to be used. Cracking heavier oils may run the cost up to as much as six cents per pound, a prohibitive figure in some petrochemical syntheses (1951). Using propane at a price of, say 5 cents per liquid gallon, the cost may be of the order of 3.8 cents per pound, whereas in making ethylene from ethane for a 90 per cent purity grade the cost may be as low as 2 cents per pound.

Two main routes of endeavor are being followed in providing ways, means, and products for many syntheses. The source for a great many chemicals is acetylene, now made almost entirely from calcium carbide via the electric furnace, at a cost of 11 cents per pound, or higher. Actual costs of more recent operations are not available to the writer. Consequently petrochemical and oil research outfits are working to develop methods for producing acetylene commercially, acetylene offering many advantages in purification ease and in chemical reactivity, to industry. Also, the adaptation of ethylene to numerous syntheses is proceeding apace. Vinyl chloride is being made from ethylene via dichlorethane and the elimination of one HCl molecule to reintroduce the double bond, this to compete with the acetylene-plus-HCl way of making vinyl chloride. Of 1951 polyvinyl production, nearly half (45 per cent) was from ethylene, the remainder from acetylene. General predictions are that both the methods for making ethylene and acetylene from hydrocarbons will undergo marked improvement technically and economically in the next few years for the decided advantage of both refining and petrochemical industries. Separation and purification of ethylene and similar hydrocarbons has been promoted recently by the development of the Hypersorption process in which olefins, etc., are adsorbed preferentially on carbon, to be released by an ingenious procedure after the contaminants have been disposed of.

Polyethylene product output has been mushrooming for several years and now such annual figures as a half billion pounds are prophesied for this country within two-three years. One adverse trend in some degree is the fact that, although raw materials up to butanes have been obtainable at fuel gas prices, heretofore, other processes such as polymerization of ethylene-to-pentenes to make high octane number motor fuels, and alkylation of isoparaffins with olefins have boosted price of these gases.

* * *



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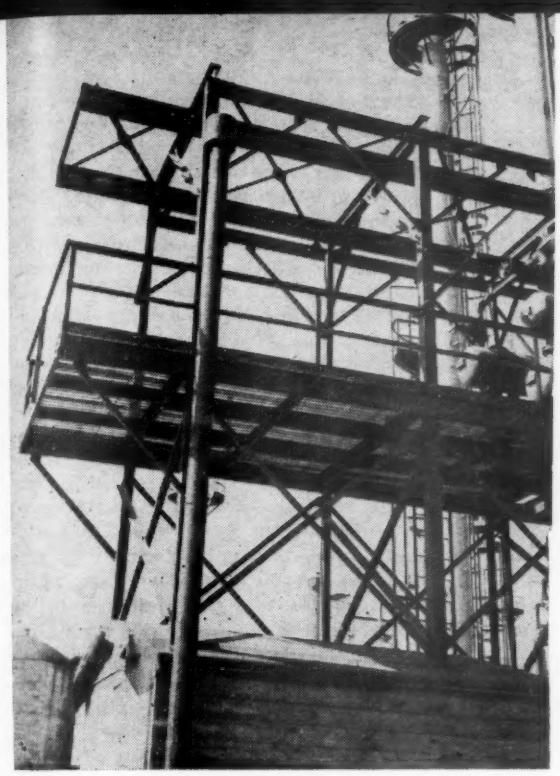
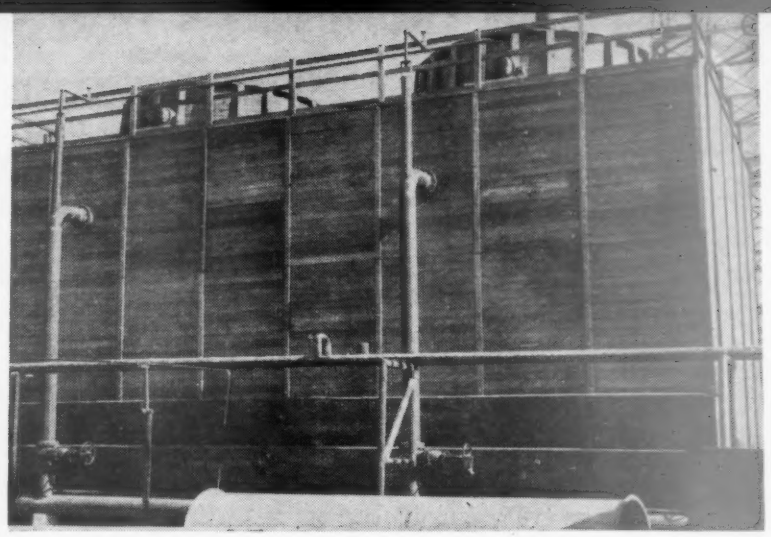




Above, one of cooling towers, Delta Refining Company, where dissolved carbon dioxide is removed from fresh well water.

Left, standpipe beside interchanger structure where another step in CO_2 removal is carried out.

EXCLUSIVE

P 735.3

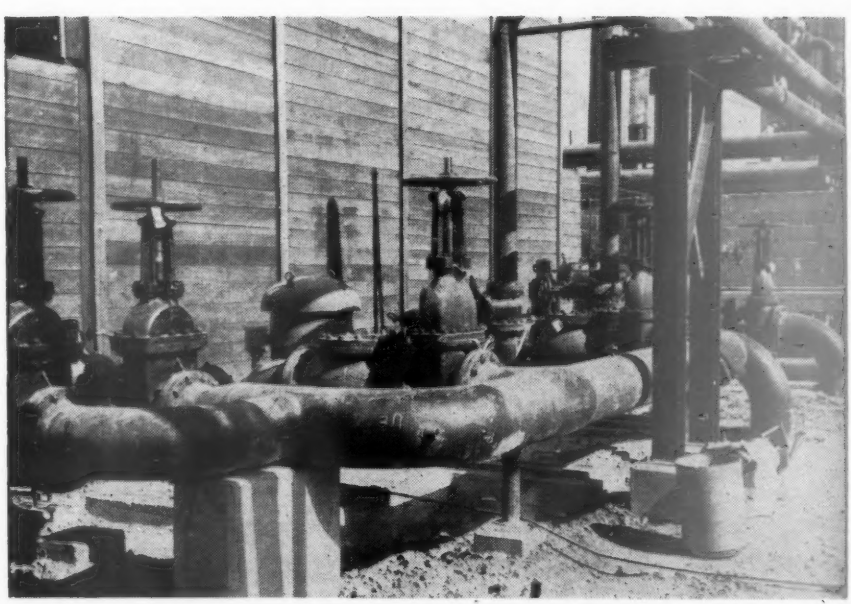
Carbon Dioxide Corrosion Reduced

Heat and aeration purifies make-up well water and replacement of equipment in circulating lines, shell and tube products coolers is small

J. C. ALBRIGHT

CORROSION of steel and cast iron pipe and fittings, due to a high saturation of the water with CO_2 has been reduced to a point that replacement of equipment is practically negligible in circulating lines and shell and tube product coolers. This has been accomplished with a system of aeration combined with the application of heat to the make-up water with water returned to the cooling towers from the refinery hot wells. Water produced by Delta Refining Company of Memphis, Tennessee, from deep wells contains all the way from 80 to 120 parts per million of carbon dioxide dissolved in the water. Experiments conducted by Delta Refining Company, and compared with results obtained by the city of Memphis, which has identical water, have indicated that corrosion of steel and cast iron fittings is of little concern if the CO_2 in solution with the water is kept below 10 ppm.

Corrosion is said to be most active in the wells themselves from the bottom of the casing up to approximately 60 ft above the impellers of the deep well



Header system at main cooling tower where severe corrosion by fresh well water occurs.

pumps. Special metals, such as various types of bronze pipe, tubing, impellers, and shafting, are installed in the "hot" zone upon completion of the wells and placing them on production. Delta Refining Company completes its fresh water wells with similar materials, and employs a gravel packed liner to relieve erosion, due to sand and finely divided formation particles moving from the reservoir to the deep well pumps.

As CO_2, or any other acid gas dissolved in water cannot be released in a solid body flowing through, and confined in a pipe line, steps have been taken by Delta to eliminate the major portion as soon as practicable after the water reaches ground level. Delta leads the fresh water, at a rate of about 450 gpm through cast iron pipe from the well head to the cooling towers. At a point where pipe size reduction is necessary, bronze pipe and fittings are used for connections. Beyond this point, and to top of cooling towers, common steel pipe is used which can be replaced easily without excessive material and labor costs.

As heat, together with aeration as used by Delta accelerates separation of CO_2 from the stream of flowing water, the company pipes the stream of make-up water to the top of the cooling tower where it enters a distribution header fitted with laterals terminating as semi-spray nozzles. These point downward into a leg attached to, and above the hot water riser which returns the hot water from process interchangers back to the cooling tower. The top of each leg is provided with an open-work, slotted bracket to which the fresh water nozzle is attached. This method permits partial aeration at the outlet of the nozzle, and supplies a constant mixture between fresh water and the main stream of hot water flowing to the cooling tower breaker decks. As the composite stream of fresh make-up, and circulated process water flows into the tower, the series of decks in the structure is said to complete aeration so that the saturation of CO_2 is below the danger point, and averages around 8 ppm. Delta uses this method only on water containing a corrosive quantity of CO_2, but it could be extended to include any refinery waters containing H_2S for similar treatment, particularly in regions where water is at a premium. * * *

Refineries Produce More Diesel Fuel for U. S.

More than 11 million barrels of diesel fuel are produced each month by U. S. refineries, according to third annual diesel fuel survey by U. S. Bureau of Mines. The survey, conducted in cooperation with American Petroleum Institute, covers 285 samples of diesel from 106 refineries and presents tabulated data in four grade groups. Diesel fuel is used increasingly for bus, truck, tractor, locomotive and marine engines. Cleanliness and comparative low cost of this oil fuel make it practical.

☆ ☆ ☆

Plant Aids

Clean-Out Plugs‡

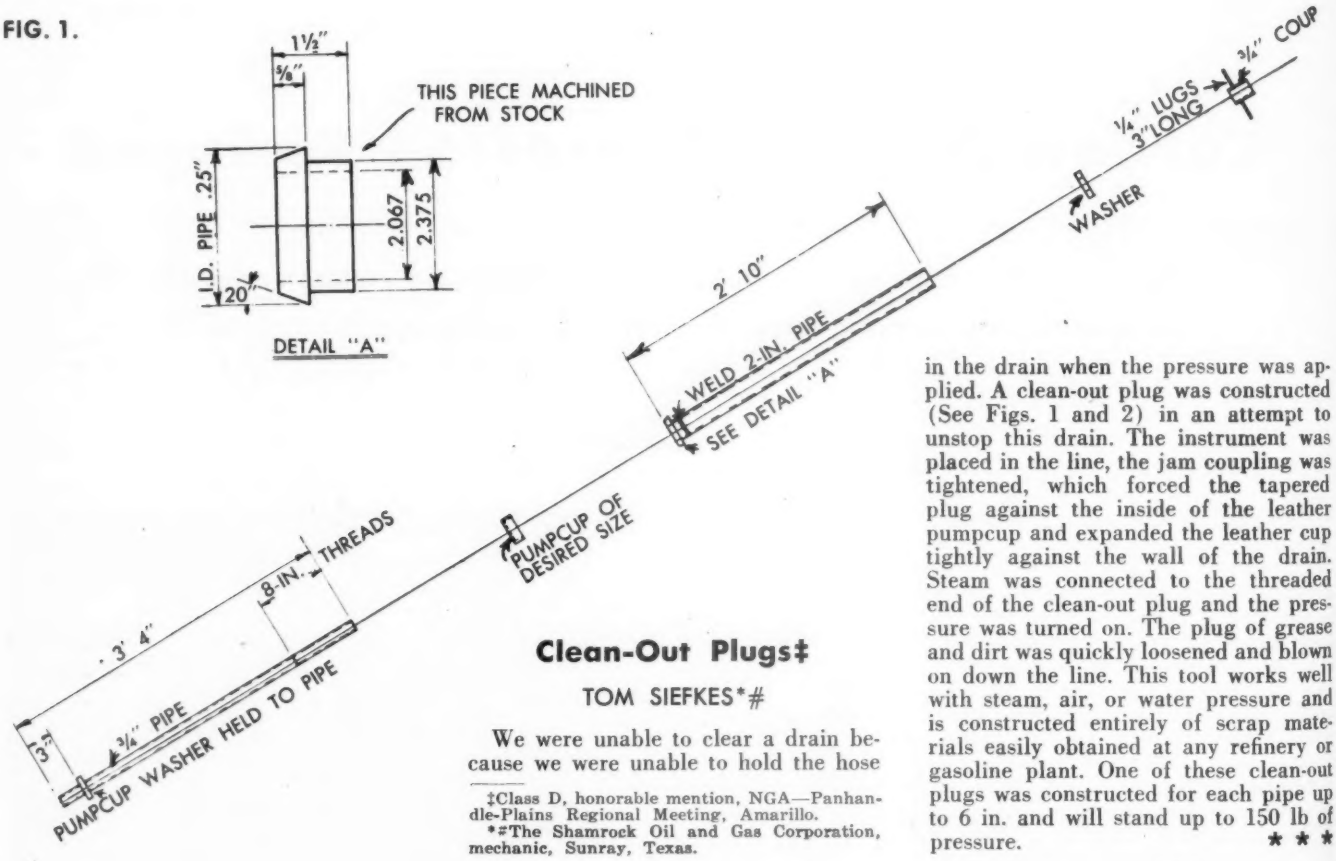
TOM SIEFKES*#

We were unable to clear a drain because we were unable to hold the hose in the drain when the pressure was applied. A clean-out plug was constructed (See Figs. 1 and 2) in an attempt to unstop this drain. The instrument was placed in the line, the jam coupling was tightened, which forced the tapered plug against the inside of the leather pumpcup and expanded the leather cup tightly against the wall of the drain. Steam was connected to the threaded end of the clean-out plug and the pressure was turned on. The plug of grease and dirt was quickly loosened and blown on down the line. This tool works well with steam, air, or water pressure and is constructed entirely of scrap materials easily obtained at any refinery or gasoline plant. One of these clean-out plugs was constructed for each pipe up to 6 in. and will stand up to 150 lb of pressure. * * *

‡Class D, honorable mention, NGA—Panhandle-Plains Regional Meeting, Amarillo.

*#The Shamrock Oil and Gas Corporation, mechanic, Sunray, Texas.

FIG. 1.



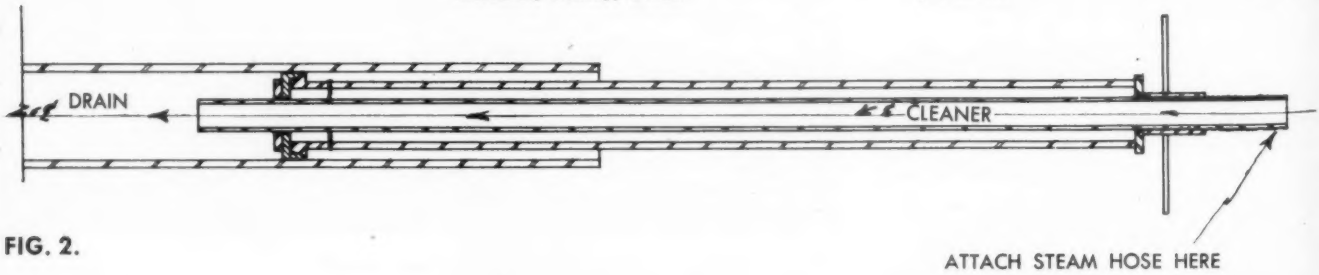


FIG. 2.

Better Valves–Year After Year

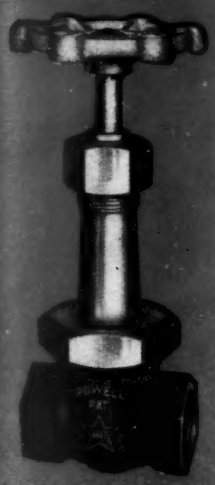


Fig. 375—200-pound Bronze Gate Valve with screwed ends, union bonnet and renewable, wear-resisting "Powellium" nickel-bronze disc.

Because throughout more than a hundred years Powell Engineers have never been willing to "let well enough alone," the Powell Line of Valves has been continually improved and expanded to satisfy every new demand of Industry.

That is why there is a greater variety of Powell Valves in service today than of any other make.

The Wm. Powell Company
Cincinnati 22, Ohio

Fig. 3003—300-pound Cast Steel O. S. & Y. Gate Valve.

Fig. 2342—Stainless Steel Swing Check Valve for 150 pounds W.P. at 500F. Also made for 300 and 600 pounds W.P. at 800F. Available in other corrosion-resisting metals and alloys. Also furnished with screwed ends.

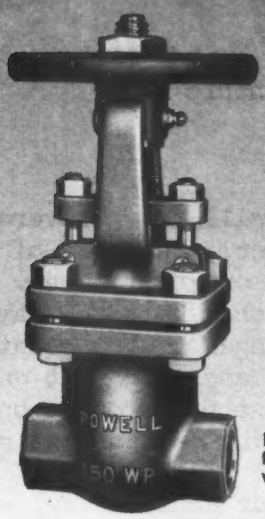
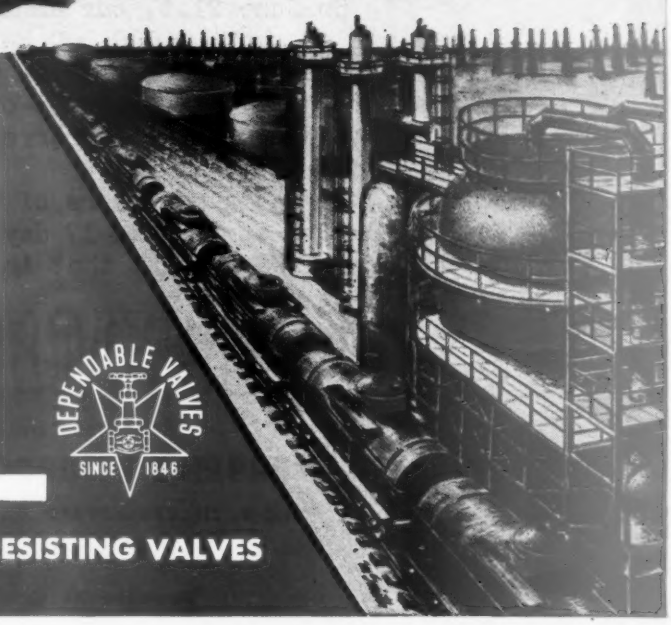


Fig. 2490—Stainless Steel O. S. & Y. Gate Valve for 150 pounds W. P. at 500 F. Can be furnished with solid or split wedge and with flanged ends.

POWELL

DEPENDABLE VALVES SINCE 1846

BRONZE, IRON, STEEL AND CORROSION RESISTING VALVES



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June 11, 1953

Universal Oil Products Company
30 East Algonquin Road
Des Plaines, Illinois

Attention: Harvey Blankenship

Dear Harvey,

This month, we will reach several milestones in the operation of our Platformer. The date of June 21st, will be the second anniversary of our operations. We are still operating on the original catalyst charge and we have reason to think that it will last some longer. Our operations indicate that we are now making more light ends and that we are getting more hydro-cracking than on past performance but our yields have remained about the same throughout our entire operation.

On June 21st, our anniversary, we will have reached a thru-put of about 1,050,000 barrels and a true platformate production of 971,250 barrels. We will have charged 160 barrels of reactor charge for each lb. of initial catalyst, at a catalyst cost of less than 2.5¢ per barrel.

During the 2 years of operation, we have been down 25 days due to strike and 17 days for inspection, minor repairs and changes. We thought that this information might be of interest and value to you.

Sincerely yours,

W. J. Leenhouts
Refinery Manager

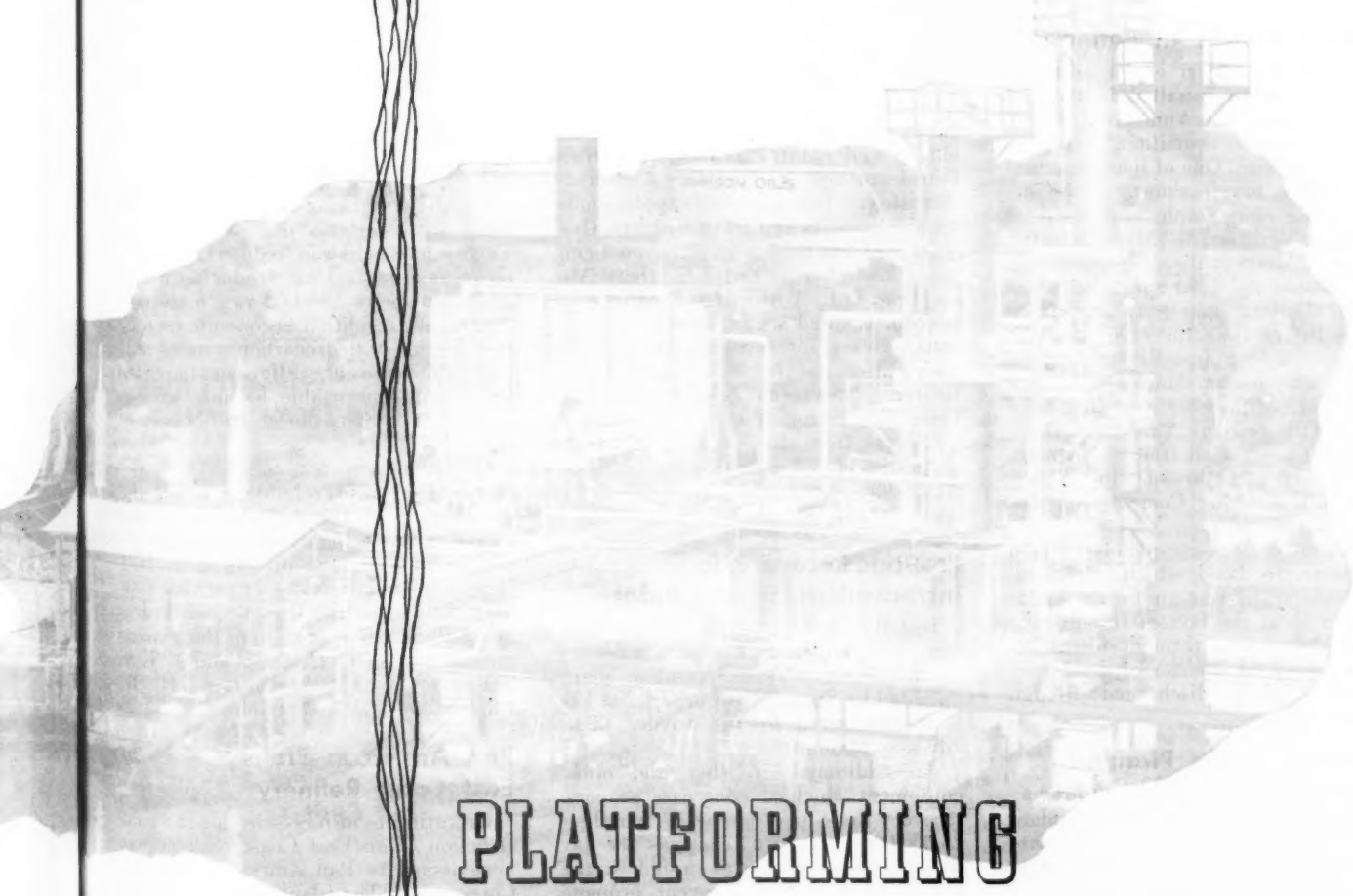
WJL/ds

XUM

YES, MR. LEENHOUTS . . .

THIS IS VALUABLE INFORMATION

TO EVERY PETROLEUM REFINER



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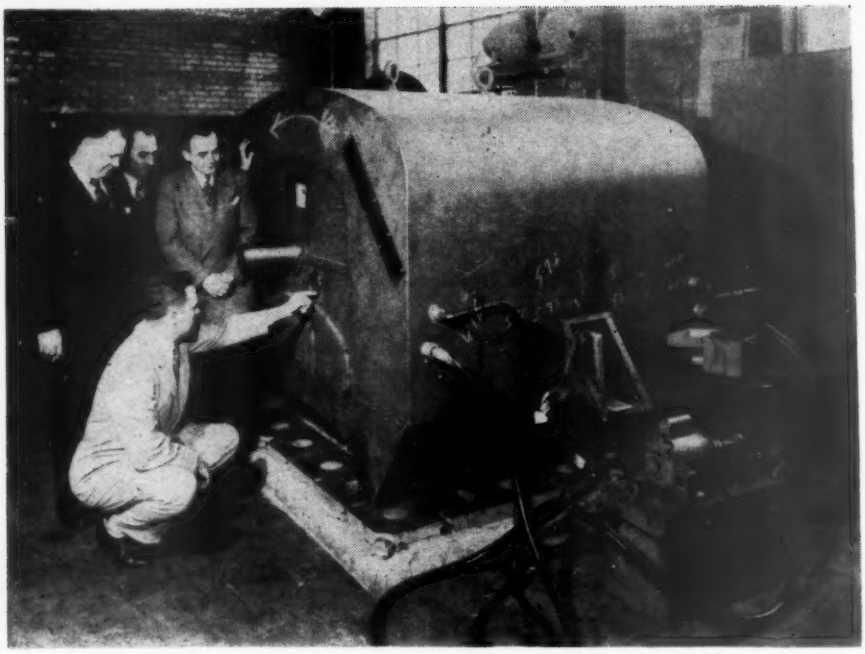

ON TEST, at factory of Electric Machinery Manufacturing Company, Minneapolis, Minnesota, is one of two 1500 hp, 1780 rpm weather-protected induction motors. These motors will drive centrifugal compressors at refineries of Imperial Oil Company, vicinity of Vancouver, British Colombia.

Outdoor Motors in Refinery

Two 1500 hp, squirrel-cage induction motors are to be installed in the Imperial refinery near Vancouver, B. C., Canada, to drive centrifugal compressors in that plant. One of these weather-protected motors is shown in the accompanying photograph, under test at the plant of Electric Manufacturing Company, Minneapolis.

These 1500 hp, 1780 rpm motors are some of the largest units to be built to date in the new weather protected design for outdoor installation without protective enclosure. Motors will drive centrifugal compressors at refineries of Imperial Oil Company, Vancouver, B. C., which will process oil from the Alberta oil fields coming through the Transmountain Pipe Line Company's transmission line.

These motors are completely covered by a protective hood, which is removable. Intake ventilating air for the motor is drawn in at the bottom through the screen, and passes through filters before reaching the interior of the motor. Ventilating air is discharged through the base.

Canadian Plants Planned

Such has been the increase of production of the Bonnyville oil refineries plant at the city of that name in Alberta, Canada, that capacity is to be augmented as soon as delivery of the essential materials can be assured. The plant has commenced the purchase of crude from the wells of Thurston Development Company Ltd. and arrangements are now under consideration to acquire that entire output of crude from those of Howard Oil Company and Lassiter Petroleum Ltd., all within the immediate area.

More than $8,500,000 will be spent within the next year and a half upon the construction of two gas absorption plants in the Edmonton area of central Alberta, for the utilization of natural gas to obtain such products as propane, butane and natural gasoline. Alberta's Petroleum and Natural Gas Conservation Board has approved applications for the construction of two plants. One submitted by Texaco Exploration Company; the other by Leduc Southern Absorption Ltd. A third application by Barcam Limited was rejected.

Texaco's plant, a $6,200,000 project, will utilize gas in the Wizard Lake-Bonnie Glen-Pigeon Lake region. The Leduc Southern unit will be near Ireton, using gas from the McLeod Kavanagh properties of Leduc; the cost to be about $2,500,000. Both plants are slated for operation in '54.

Propane Recovery to Be Increased at Snyder Plant

Installation of additional processing facilities to increase propane recovery at the Snyder, Texas, gasoline plant operated by Sunray Oil Corporation has been announced by the Snyder plant advisory committee.

An additional absorber and other equipment which will increase propane recovery to 76 per cent while handling 75,000,000 cu ft of natural gas per day will be installed. Initial design of the plant called for 70 per cent propane recovery while handling 50,000,000 cu ft of gas per day. Estimates indicate that at 75-million cubic feet of throughput, the Snyder plant will produce an additional 100,000 gallons per day of propane. When the new installation is completed on this basis of throughput, the plant's total liquid production should be approximately 625,000 gal per day.

Hydraulics Conference Program Announced

Program for the ninth National Conference on Industrial Hydraulics at the Sheraton Hotel, October 8 and 9, has been announced by conference secretary John G. Duba, assistant professor of civil engineering at Illinois Institute of Technology.

The instrumentation session will consist of papers on, "Pressure Transducers," by R. E. Boyar, Askania Regulator company, Chicago, Illinois; and "A Flowmeter for Measuring Mass Flow-Rate with High Speed of Response," by Dr. Yao Tzu Li, Massachusetts Institute of Technology, Cambridge, Massachusetts.

Canadian Refinery Planned

Plans to construct a new $10,000,000 refinery near Vancouver, B. C., were announced by T. S. Petersen, president of Standard Oil Company of California. The new plant, designed to utilize Canadian crude oil, will be constructed and operated by Standard of British Columbia, a wholly-owned subsidiary.

It is planned that on completion, late 1954, the refinery will process about 11,000 bbl of Alberta crude daily to make aviation and motor gasolines, as well as asphalt and fuel, diesel, and heating oils.

IGT Publishes Study Of Catalytic Activities

Catalytic cracking of natural gas and other hydrocarbons of low molecular weight has achieved industrial importance as a method for producing utility gases and petrochemical raw materials. Emergency conditions, economic factors, or depletion of hydrocarbon sources may necessitate charging sulfur-contaminated stocks not now usable because of loss of catalyst activity due to sulfur poisoning.

Results of a search, conducted by the Institute of Gas Technology under the sponsorship of the American Gas Association, for a highly active, sulfur resistant catalyst, are presented in IGT Research Bulletin No. 4, "Cracking Catalyst Activity in the Presence of Hydrogen Sulfide," prepared from the experimental data of C. H. Riesz and J. J. S. Sebastian by H. A. Dirksen, H. R. Linden and E. S. Pettyjohn.

Pan American Plans East Coast Refinery

A Certificate of Necessity for the construction of an East Coast refinery has been issued to Pan American Refining Corporation. The plant site specified in the Certificate is on the Delaware River near Pedricktown, New Jersey. Company officials stated, however, that engineering studies of that site and of other possible sites are still in progress. Pending completion of these studies, the company is holding in abeyance its final decision as to the location of its East Coast refinery.

HIGHLIGHTS OF THE FIRST SIX MONTHS OF 1953

FROM— CHEMICAL PROCESS NEWS / REFINERY PROCESS NEWS

Cascade Reactor, Recently Introduced, Is Highly Successful in Alkylation Plants

For example, two years ago Kellogg brought out its new cascade reactor for sulfuric acid alkylation. Peculiar only to Kellogg designs, this reactor provides a most desirable high ratio of iso-butane to butylene without the additional expense of extensive iso-butane recycling equipment required in conventional plants. In addition, the overall plant design maint[illegible]s acid consumption [illegible]ssible [illegible]uto- in-

Three of these new reactor designs have now been put into service. A fourth will be the heart of a contract for the design and erection of a new plant in a Rocky Mountain refinery. Experience with the novel reactors, which have undergone even further refinements since the first was installed two years ago, has shown exceptionally

Simple Change in Orthoflow Unit Radically Reduces Catalyst Loss!

A comparatively simple modification in the regenerator of the first domestic Orthoflow unit has radically reduced amount of catalyst lost with stack gases. Tests over a period of better than two months prove that the catalyst loss factor of the Orthoflow is now [illegible] that of the best side-by-side [illegible] yields from this [illegible] the best

First Model "B" Orthoflow Unit Completed Soon

Shown here as it passed the 75%-completion point is the first of the new type Orthoflow Fluid catalytic crackers. It is currently about to be placed on stream at a major Midwestern refinery.

Known as the Model "B" Orthoflow, it is a variation of the original Orthoflow design. Principal reason for the new design, with the regenerator above the reactor, is the expected reduction in the operating costs in comparison with the conventional Model "A" [illegible] of which are now opera[illegible]

Sinclair-Baker Catalyst Promises Substantially Lower Operating Costs and Increased Yields

Employing the recently announced Sinclair-Baker platinum catalyst—a joint development of Sinclair Research Laboratories, Inc. and Baker & Company—Kellogg's new catalytic reforming process is expected to produce excellent yields of high [illegible]ctane product from a wide variety [illegible]era-

tive type and has two major advantages over existing commercial platinum catalysts: (a) the catalyst maintains high activity over considerably longer periods of time, resulting in substantially lower catalyst operating costs, and (b) it has a greater ability to convert low octane paraffinic components to high octane aromatics.

Lower Initial Investment, Decreased Operating Cost with New Urea Process

A new, low-cost method of producing synthetic urea of exceptional purity from ammonia and carbon dioxide is now available in the United States through Kellogg. Known as the Montecatini Urea Process—after the well-known Italian firm which developed it—the method reflects more than 30 years of experience in nitrogen chemistry.

[illegible]atures of [illegible]

Montecatini process is the reduction in operating cost due to the virtual elimination of the corrosion problems generally associated with urea synthesis. This is accomplished not only through judicious materials selection but also through the use of relatively mild operating conditions in the reaction zone in comparison with other [illegible]urea [illegible]

Capital Investment Lowered in Phthalic Anhydride Plants

Several design improvements which lower capital investment are being incorporated in new Fluid phthalic anhydride plants now underway for two major chemical companies abroad.

Most important is a re-design of the condensing system which not only reduces capital investment but also improves operating conditions. For example, it precludes any need for operators to come in direct contact with the phthalic or its fumes.

When completed the two new plants will produce about 50 million pounds [illegible]annually.

New Sulfur Removal Process Promises Maximum Oil Yield

Because of the increasing volume of high sulfur crudes being produced, many refiners have shown considerable interest in the new desulfurization process—Autofining—which has been developed and commercially tested by the Anglo-Iranian Oil Company, Ltd.

The Autofining process—licensed on a world-wide basis by Kellogg—has several advantages over [illegible]nal acid [illegible]er-to-[illegible]ter in [illegible]s [illegible]k [illegible]!

High Pressure Gas Reforming Slated for West Coast Ammonia Unit

A special high-pressure gas reforming plant will be the feature of a new ammonia plant Kellogg is currently erecting for a West Coast processor. Shown here during construction, the unit will produce well over 300,000 pounds of anhydrous ammonia daily from a natural gas feed stock.

The result of pilot plant studies by Kellogg, the reformer section of the plant makes use of the fact that natural gas is usually [illegible]available [illegible]at [illegible]

high pressure. Rather than design the reformer for operation at conventional low pressure and thus produce low pressure synthesis gas, Kellogg engineered this section to conserve the potential energy of the natural gas. Although the synthesis gas must be still further compressed before it is charged to the converter, the new high pressure reformer will save about 25% to 35% on compressor horse[illegible]

Changing Product Economics Increases Interest in Delayed Coking Process

In view of the deteriorating market for residual fuel oil in certain areas and no indications that it will greatly improve in the future, refiners in many parts of the country are reaching the decision that a coking step is the most logical solution to this economic problem.

Not only has the moderate winter piled up supplies of residuals in [illegible]ions of the country but [illegible]ived

Petroleum coke is marketable today in virtually every part of the country — in contrast with the situation a few years ago when it had value only as refinery fuel in a number of locations. Further its price ranges as high as $10 a ton or more, depending on quality. In addition to customary uses, there is an increasing demand for petroleum coke in the manufacture of the carbon electrodes used in alu[illegible]. Roughly seven[illegible]

Greatly Reduced Coking and Improved Yields in Kellogg's Unique Ethylene Process; New Pyrolysis Method Adaptable to Ethane

Whereas conventional ethylene pyrolysis furnaces usually average only a few weeks on-stream before being shut down for coke removal, this plant showed only slight coke deposits when inspected after 12 months continuous operation. During this period it was operated with sufficient severity to convert 55 to 60 wt. % of the naphtha to C-4's and lighter gaseous products.

Meanwhile continuing pilot plant studies are being carried out in the Kellogg labs on using various adaptations of this pyrolysis process to produce high purity ethylene from ethane, propane and other feed stocks. Test runs indicate that the Kellogg method will produce higher yields of ethylene and less coke than conventional processes.

For further information, technical data, etc., on any refining process, write

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KELLOGG PULLMAN

UNDER CONSTRUCTION at the Shell Petroleum Company's Stanlow refinery, Ellesmere, Port Cheshire, Great Britain, is a $10,000,000 Platformer. The plant will reform low grade oil into high grade suitable for blending into high-octane spirit. Plant consists of feed preparation, reaction, and stabilization sections.

Britain's First Platformer Is Under Construction

A $10,000,000 Platformer for the reforming of low grade oil into high grade suitable for blending into high-octane spirit is under construction at the Shell Petroleum Company's Stanlow refinery, Ellesmere Port, Cheshire, Great Britain.

It is the first of its kind to be built in Great Britain and is scheduled to go on-stream late this year.

Plant consists of feed preparation, reaction, and stabilization sections. In first selected gasoline feedstocks are purified and distilled to remove light and heavy ends. Heart-cut is then fed to reaction section and heated to moderate pressure and passed through a series of reactors containing platinum catalyst supported on inert material. Reactor products are cooled and hydrogen formed during reaction is separated, compressed, and recirculated to reactors with feedstock. In last section lighter fractions are removed by distillation and the platformate is then blended into high-octane spirit without further treatment.

Construction of Platformer supplements a post war expansion program which has increased Shell's British refinery capacity from 1,000,000 tons to 9,000,000 tons annually.

Cracking Catalyst Use May Double by 1955

Consumption of catalysts in catalytic cracking operations of United States and free-world petroleum refineries is expected to reach a level by January 1955, almost double the consumption in 1952, according to an industry survey just completed by the Petroleum Administration for Defense.

In making public the results of the survey, Associate Deputy Petroleum Administrator C. E. Davis said that despite the projected increase in consumption, the supply of catalysts — of both fluid and pellet types — is expected to be substantially equal to the requirements estimated for the beginning of 1955.

Nevertheless, Davis said, additional expansion to provide more capacity for manufacturing both types of catalysts may prove to be desirable as a reserve for wartime emergency.

The supply-demand outlook for fluid and pelleted catalysts is summarized in the following table:

Catalytic Cracking Catalyst Position

United States and friendly foreign countries

	Fluid operations		Pellet type operations	
	Installed cracking capacity B/D	Catalyst requirement T/Mo	Installed cracking capacity B/D	Catalyst requirement T/Mo
1951 actual	1,636,000	9,043	572,000	3,665
1952 actual[1]	1,815,000	10,800[1]	570,000	3,440
January 1955				
Estimated requirement	2,810,000	18,300	956,000	6,850
Visible catalyst supply		17,850		6,730[2]

[1] Capacities shown make allowance for 1952 strike.

[2] Based on 30 per cent higher unit catalyst use for airlift units than for mechanical lift units.

Standard Uses Faculty Men for Consultants

Seven scientists and engineers from the faculties of midwest universities have been retained as summer consultants in the research laboratories of Standard Oil Company, Whiting, Indiana. They will return to their teaching at the opening of fall terms.

They are Harold Hart, Michigan State College, Gerald W. Lawton and Robert S. Kirk, University of Wisconsin, John M. Woods, Purdue, Murlin T. Howerton, Notre Dame, Gilbert P. Haight, University of Kansas, Ray T. Wendland, North Dakota Agricultural College.

Joseph K. Roberts, general manager of research and development for Standard Oil, said this is the first year the company has engaged university scientists for research work during their summer vacations.

API Samples Available

Compounds listed below are newly available as API Standard samples as of July 1, 1953.

Orders for American Petroleum Institute Standard samples should be addressed to

Carnegie Institute of Technology
Attention of Frederick D. Rossini
Petroleum Research Laboratory
Pittsburgh 13, Pennsylvania

American Petroleum Institute

Standard Sample of Hydrocarbons

Sample number[1]	Compound Formula	Compound Name	Amount of impurity[2] mole per cent	Vol. per unit[3] ml (liq)	Price per unit $
1029-58	C_7H_{14}	2, 3-Dimethyl-1-pentene	0.20±0.15	5	50.00
1030-58	C_8H_{14}	Ethenylcyclohexane (Vinylcyclohexane)	0.05±0.04	5	50.00
1031-58	$C_{12}H_{18}$	1, 4-Diisopropylbenzene	0.03±0.03	5	50.00

[1] The designation "-58" following the sample number indicates a sample of 5 ml sealed "in vacuum" in a special Pyrex glass ampoule with internal "break off" tip.

[2] The purity has been evaluated from measurements of freezing points in accordance with the method and procedure of the American Petroleum Institute Research Project 6, as described in J. Research Natl. Bur. Standards 35, 355 (1945), and Anal. Chem. 20, 410 (1948), unless otherwise noted.

[3] Tolerance approximately ±10 per cent.

Chemical Industries Show To Be Held in Philadelphia

Announcement has been made that the Exposition of Chemical Industries, held in New York almost continuously since 1915, will move to Commercial Museum and Convention Hall in Philadelphia for its 24th biennial run, November 30 to December 5. A substantial increase in exhibit area will make it the largest display of its kind ever held. Many former exhibitors are taking advantage of the new move by planning expanded layouts, while nearly one hundred new exhibitors have already engaged space.

The forthcoming exposition, like its predecessors, will be managed by the International Exposition Company, of New York. Charles F. Roth is manager, and E. K. Stevens associate manager.

Sulfur Recovery Unit Uses 100 Per Cent Waste Gas

A new sulfur recovery unit of Gulf Oil Corporation produced 12,750,000 lb of sulfur in Waddell, Texas, in its first year of operation, the company stated in the first public report about this installation. The unit was also described as "completing 100 per cent utilization of casinghead gas from nearby company fields."

Designed to be one of the most efficient of its type, the unit was placed in service June 12, 1952 as an addition to the company's Waddell natural gasoline plant.

CSMA to Hold 40th Meeting

The Chemical Specialties Manufacturers Association, Inc. will hold its 40th annual meeting in Washington, D. C. on December 6-8, 1953, at the Mayflower Hotel. Original association from which the CSMA developed was organized in Washington in 1914. There are now 300 members.

Tide Water Group Meets

Eighth annual research and development conference of the Eastern and Western divisions of Tide Water Associated Oil Company was held at the company's Bayonne, New Jersey, refinery recently.

John T. McCoy, general supervisor of research and development for the Eastern division, presided. The Western division representatives were C. K. Viland, general supervisor of research and development, Dr. L. S. Galstaun, supervisor of research, C. F. Becker, supervisor of automotive laboratory, and F. C. Dramel, supervisor of development.

ATTENDING SUMMER COURSE in Montreal are: John Spence and Claude Bourgeois, mechanical engineering, McGill University, Montreal; Stanley Boyes, chemical engineering, University of Toronto; Hugh Barclay, engineering, McGill U.; Jacques Plante, science, U. of Montreal; Andrew Tekela and Ian Davidson, science, Sir George William College, Montreal; Morris Givner, and Vivian Chrom, science, McGill U.; William Coughlan, science, Mount Allison U., Sackville, New Brunswick; John Jones, pre-med., McGill U.; Andrew Thimens, chemical engineering and James Dunn, engineering, and Kenneth Read, chemistry, McGill U. Left background, Tom Peake, and supervisor, Pete Pangman.

B-A Grease Plant Adds To Canadian Output

Canada's grease manufacturing capacity has been increased by 15,000,000 lb annually, according to announcement by British American Oil. This added domestic production will reduce, to a large degree importation of grease from the U.S.

A new modern grease plant, built at the company's Clarkson refinery, has advanced scientific and industrial features for pre-testing and large-scale production of greases.

Canadians Attend Shell Short Summer Course

Canadian professional and technical men, representing diverse pursuits at leading universities and colleges of the Dominion, are enrolled in a student summer course at the Shell Oil Company of Canada Ltd. Montreal East refinery.

The summer course this year has attracted a greater collegiate attendance, particularly by reason of the emphasis placed upon the petroleum refinery's significant contribution to the petrochemical industry, one of the newest and laregst units of which was recently inaugurated on premises immediately adjacent to Shell's Montreal East refinery.

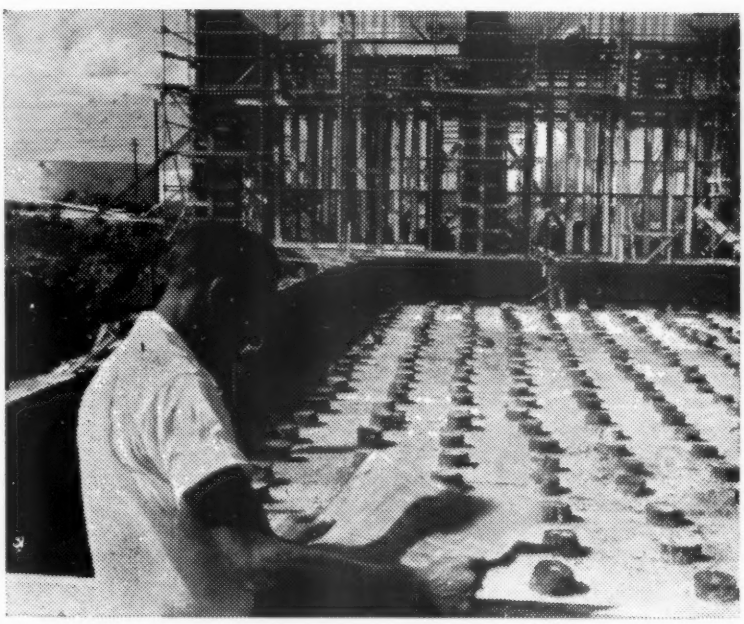
Safety Record Set

A new West Coast refinery safety record of 3,000,000 man-hours without a lost-time accident has been established by employees of the Richmond Refinery of Standard Oil Company of California. Richmond's previous safety record was 2,723,310 man-hours without a lost-time mishap.

Facilities for Testing Fuels, Lubricants Are Completed

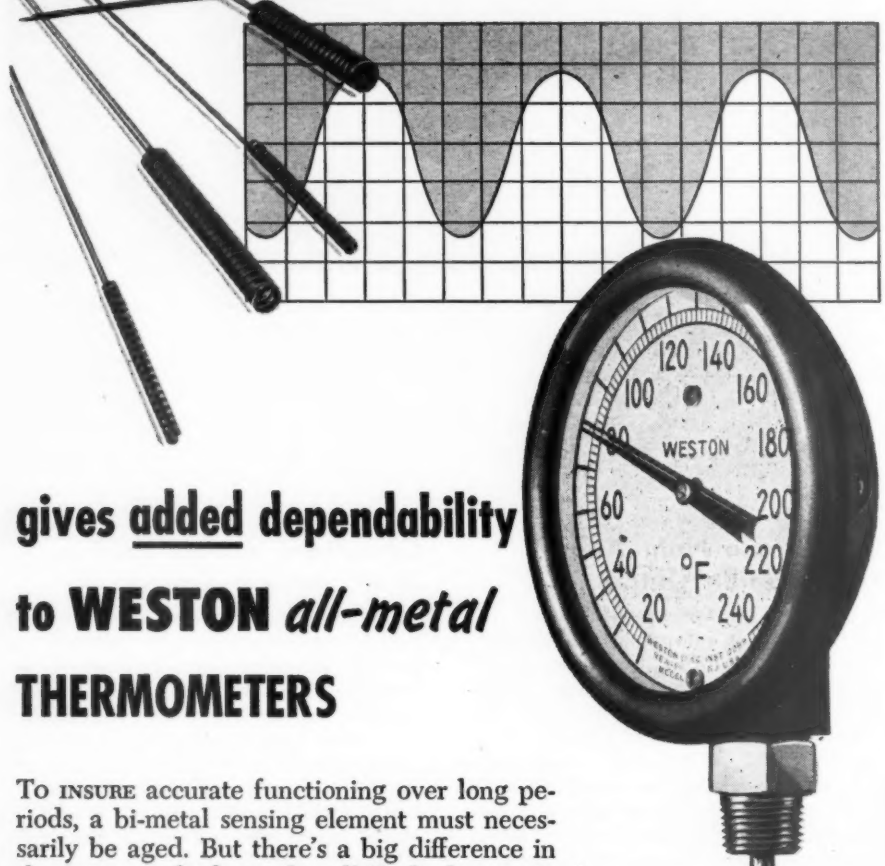
Standard Oil Company (Indiana) has added a new building—with complete facilities for full-scale engine testing of automotive fuels and lubricants—to its extensive automotive laboratory at Whiting, Indiana, it was announced by Joseph K. Roberts, general manager of research and development.

The new building and dynamometer laboratory are adjacent to other buildings in Standard's research center at Whiting, where the company's continuing program for developing new and improved automotive fuels and lubricants is conducted.



A TRANSPLANTED FOREST—A new refinery needs plenty of support. These piles are a part of the more than 6800 tree trunks from Louisiana forests being driven into the ground to support heavy new units of Shell Oil Company's refinery expansion at Norco, Louisiana. Some 100 of these 40 to 50-ft long piles, are driven into the soft refinery soil in the course of an average day. Shell's refinery will have expanded output from 2,100,000 to 3,150,000 gal of product a day.

Cycle-Seasoning...



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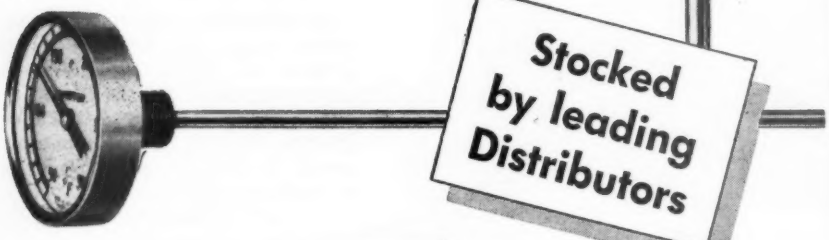
Thermometers with the MULTIPLE HELIX



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News

New Coking Unit Planned

Sunray Oil Corporation has announced plans to build a 9000-bbl per day delayed coking unit at Sunray Village (Duncan, Oklahoma) in conjunction with the company's 25,000-bbl per day refinery with catalytic cracking facilities operating at that point.

The new plant on which planned construction should begin this month with completion scheduled in the fall of 1954 will be planned, engineered, and operated by Sunray Oil Corporation for the Ucan Products Company, a recently organized corporation in which Sunray has a 50 per cent stock ownership.

Upgrading of residual No. 6 fuel oil into more valuable demand products and a more flexible refinery operation, will be a prime benefit to Sunray.

Shell to Build Refinery In Washington State

Anacortes, Washington, has been chosen as the site for a new refinery Shell Oil Company plans to build in the Northwest, according to an announcement by R. W. McOmie, Wilmington refinery manager and Shell's West Coast refinery coordinator.

McOmie stated that engineering studies undertaken by Shell developed the availability of adequate water, power, and harbor facilities at March's Point. March's Point is on the outskirts of Anacortes, and the area provides an excellent refinery site, he stated.

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REFINING AND PETROCHEMICAL PERSONALS

R. Rea Jackson, who has been director of the refining and natural gasoline division of the Petroleum Administration for Defense since last February, has been named assistant deputy administrator in charge of domestic petroleum operations, Deputy Petroleum Administrator J. Ed Warren announced. **Paul E. Kuhl,** director of PAD's foreign refining division, will also head the refining and natural gasoline division, Warren said.

Jackson worked for the Socony-Vacuum Oil Company, Inc., from 1923 until the time he came to PAD. From 1936 to 1947 he was general superintendent of the Beaumont, Texas, refinery of Magnolia Petroleum Company, an affiliate. From 1947 to 1950 he was general manager of Socony's refinery at Paulsboro, New Jersey. In September 1950, he was named a member of the company's manufacturing committee, which supervises and coordinates refining operations.

Kuhl has worked in the petroleum industry since his graduation in 1926 from the University of Pittsburgh. Beginning as a student engineer with Standard (New Jersey), he was appointed in 1932 as assistant superintendent of the Aruba, Curacao, refinery of Lago Oil and Transport Company, in charge of technical groups. Kuhl was named assistant general manager of the East Coast division of Esso Standard Oil Company in February 1949, and in November 1950 became assistant general manager of manufacturing for Esso Standard.

Albert L. Anderson, Sun Oil Company, has been appointed chief of Aviation Fuels Branch, refining and natural gasoline division, PAD. Anderson will serve with the PAD while on leave from Sun where he was special assistant to the manager of refinery supply and distribution department.

A. Ludlow Clayden, an authority on fuels and internal combustion engines, has retired after 31 years of service with Sun Oil Company. Clayden joined Sun as chief automotive engineer in May, 1922. In 1948 he became head of the Automotive Laboratory at the Marcus Hook, Pennsylvania, refinery and in February of this year became technical associate in the chemical research and development department.

Born in Bath, England, in 1883, Clayden studied mechanical and electrical engineering at Bristol University in Bristol, England.

R. E. Lauterbach

C. G. Cortelyou

V. M. Stanich

Richard E. Lauterbach has been named manager of General Petroleum Corporation's manufacturing department. Since last November Lauterbach has held the position of manager of the company's new Ferndale refinery which is now under construction.

In his new post Lauterbach will make his headquarters at General Petroleum's home office in Los Angeles.

Lauterbach is a graduate of the University of California at Los Angeles. He joined General Petroleum in March, 1936, immediately after graduation. After three years as a laboratory assistant he became a chemical engineer in the laboratory department. In 1945 he was assigned to the company's Torrance refinery as a refinery engineer. He became assistant refinery manager in 1950.

Two executive appointments for the new Ferndale, Washington refinery have been announced.

They are: **Curtis G. Cortelyou** has been named manager of the plant which is now under construction.

V. M. Stanich has been appointed chief engineer.

In his new post Cortelyou succeeds Lauterbach. He has been with General Petroleum since 1938, not long after his graduation from the California Institute of Technology. After working as a laboratory technician he became measurement engineer in 1940.

Stanich joined General Petroleum in 1937 in laboratory work. He has served as a lubrication engineer, a chemical engineer, and a refinery engineer. He is a graduate of Montana State College.

M. F. Miller has been appointed manager of operations for the Richmond (California) refinery of Standard Oil Company of California. He succeeds **J. T. Higgins,** recently elected president of two Standard subsidiaries, Salt Lake Refining Company and Salt Lake Pipe Line Company.

Miller, a graduate in chemistry from the University of California, joined Standard in 1926, immediately after completing college. Prior to his new assignment he served as assistant manager, operations control division, of the company's manufacturing department in San Francisco.

Succeeding Miller will be **J. S. Detweiler,** who has been technical assistant in the Operations Control Division in San Francisco. He joined the company in 1934 and holds a BS degree in chemical engineering from California Institute of Technology.

Also appointed a new assistant manager of the same division was **T. M. Sheehy,** previously assistant superintendent of the light oil division at El Segundo refinery. Sheehy joined Standard in 1937 after receiving his master's degree in chemical engineering from the University of Washington.

H. E. Cotton, general superintendent of Standard's Casper, Wyoming, refinery, has been named manager at Wood River, Illinois refinery, by Standard Oil Company. He succeeds **Dr. G. F. Ordeman,** who retired on annuity August 1. **L. H. Butterworth,** manager of the operations and cost control division of the manufacturing department in the company's general office at Chicago, Illinois, will be advanced to general superintendent at Casper. **F. C. Smith,** superintendent of the operations and cost control division, will be promoted to manager. Dr. Ordeman joined Standard in 1919 as a chemist at Whiting, Indiana. He was promoted to assistant general superintendent of the Whiting refinery in 1943, and advanced to manager at Wood River in 1946.

Cotton was first employed at Casper by the Midwest Refining Company as chief draftsman in 1919. The operations of this refinery were assumed by the Standard Oil Company in 1921, and he was promoted to general superintendent of the Casper refinery in 1938. Butterworth joined Standard in 1937 as a chemical engineer in the research department at Whiting. In 1952 he was appointed to a new position as manager of operations and cost control of the manufacturing department in the company's general office at Chicago. Butterworth received his bachelor of science degree in chemical engineering from the University of Iowa.

Smith became associated with the company in 1943 as a chemical engineer at Whiting. He was appointed a technical assistant in the projects division in 1946 and in the same year was advanced to assistant general foreman in the pressure stills department, light oils division. He was made section supervisor in 1948 and superintendent of the operations and cost control divisions in 1951.

Personals

N. F. Myers

Norval F. Myers, managing director of Esso Petroleum Company, Ltd., London, has been appointed deputy coordinator of refining activities for Standard Oil Company (New Jersey) with headquarters in New York. Myers has been affiliated with Esso Petroleum, Jersey Standard affiliate formerly known as Anglo-American Oil Company, Ltd., since 1949. During that period he participated in the construction, operation, and expansion of the Fawley refinery. Previously, he was assistant chief of the Standard Oil Development, Linden, New Jersey, central research affiliate of Jersey Standard. Myers is a graduate of Beloit College, Princeton University, and Massachusetts Institute of Technology.

Paul Stefanik, formerly chief engineer of the chemical products group of the lubricating department, Socony-Vacuum Oil Company, Inc., has been transferred to the lubricating and allied products staff of the company's foreign trade department. His new duties include coordination of chemical products activities in Europe.

Warren A. Beman, formerly in charge of chemical development and by-products activities of the chemical products group, succeeds Stefanik as chief engineer of this group.

Glenn A. Stankis, University of California graduate, has been added to the research and development division of Humble Oil and Refining Company's Baytown, Texas, refinery. Other new employees include: **Egbert W. Biggers,** BS in chemical engineering, University of Illinois; **Jerry G. Jenkins,** BS in chemical engineering, Texas A & M College; **William N. Lyster,** BS in petroleum refining engineering, Colorado School of Mines; **Wayne F. Mardis,** BS in chemical engineering, University of Alabama; **Bruce A. Martin,** BS in chemical engineering, Louisiana State University; **Fred S. McDonald,** BS in chemical engineering, Mississippi State College; and **Paul D. Meek,** BS in chemical engineering, The University of Texas, to technical service division.

Charles S. Lloyd, BS in chemical engineering, University of Florida, was re-employed on the staff of technical service division after serving since 1951 in the U. S. Air Force. His tour of service was the research and development command at Wright-Patterson Air Base.

John B. Calkin, chemical engineer and consultant with offices in New York City, has been named assistant to the president, Foster D. Snell, Inc., of New York City. He will also be director of market research. This appointment follows a long time connection of Calkin with the firm. He has recently been associated with the University of Maine where he was director of the department of industrial cooperation and secretary, The University of Maine Pulp and Paper Foundation. He is an associate professor of chemical engineering.

Harvey N. Frost of Beaumont, Texas, has been appointed chief of the Petroluem Products Supply Branch, the Refining and Natural Gasoline Division of the Petroleum Administration for Defense. Frost succeeds **James E. Lee** of Chester, Pennsylvania.

Frost has worked for Pure Oil Company since 1933 and for a number of years has been chief chemist at the company's Nederland, Texas, refinery. He attended Texas Christian University at Fort Worth, Texas, and in 1929 was awarded a BS degree in chemical engineering from the University of Texas, at Austin, Texas. In 1929-30 he was plant engineer for the Texas Pacific Coal and Oil Company at Fort Worth. From 1930 to 1933 he was chief chemist and chemical engineer for the Champlin Refining Company at Enid, Oklahoma.

Dr. Gustav Egloff, of Universal Oil Products Company, has been appointed a member of the Washington Award Commission of the Western Society of Engineers, 1953-1956. He is also a national director of the Armed Forces Chemical Association for 1953-1954, and a member of the Advisory Committee, Midwest Chapter, of the Armed Forces Chemical Association, 1953-1954.

Lester H. Barnes, mechanical superintendent at Continental Oil Company's Ponca City, Oklahoma, refinery, was promoted to assistant refinery superintendent in charge of the mechanical department. He succeeds **H. G. Gunter,** who has resigned from the company.

Loyd Thompson, chief planner, was promoted to mechanical superintendent, succeeding Barnes.

Barnes received his electrical engineering education at Oklahoma A. & M. College and joined Conoco at Ponca City in 1928. He served as an electrician at the Ponca City refinery until 1940, when he transferred to Lake Charles, Louisiana.

He returned to Ponca City in 1942 as an electrician foreman and was promoted in 1950 to mechanical superintendent.

Thompson received his bachelor's degree in mechanical engineering in 1929 from Oklahoma A. & M. College. He joined Conoco at Ponca City in 1937, transferring later that year to Wichita Falls, Texas, as resident engineer. He became resident engineer at Lake Charles in 1940. He transferred to Denver, Colorado, in 1947 as a construction engineer and returned to Ponca City two years later in the same capacity. He was promoted in 1950 to chief planner at the Ponca City refinery.

William F. Boone, division engineer at Continental Oil Ponca City refinery, has been promoted to resident engineer at the company's Baltimore petrochemical plant, it was announced by James G. Hough, general superintendent.

Conoco's Baltimore petrochemical plant produces raw materials for use in the manufacture of synthetic soaps.

Boone received his bachelor's degree in mechanical engineering in 1942 from Oklahoma A. & M. College. He joined Conoco at Ponca City following graduation from college and held a succession of refinery positions before his promotion to division engineer in 1950.

T. A. Petry has been named supervisor in the development division of Socony-Vacuum Oil Company, at Paulsboro, New Jersey.

H. E. Rasmussen becomes assistant supervisory of the refining section.

D. P. Heath was named assistant supervisor of the fuels and lubricants section, and **R. R. Halik** and **L. M. Browning** become research associates in the process development section.

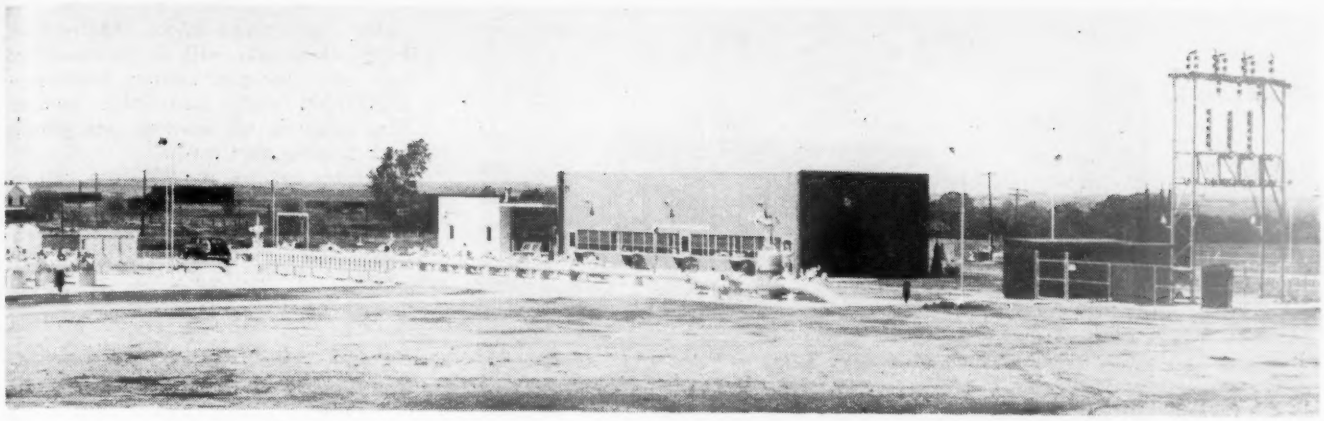
Herman G. Gunter has been named vice president - refining operations for Suntide Refining Company, Corpus Christi, Texas, it was announced by

H. G. Gunter

Floyd L. Martin, president. Gunter, a veteran of 23 years' refining experience has served in many capacities throughout the industry.

After studying engineering at John Hopkins University, Gunter joined Standard Oil Company of New Jersey in 1930 as an analyst in the chemical laboratory of the Baltimore refinery and worked up through this large plant to process superintendent. He has been associated with fluid catalytic cracking, polymerization, and alkylation since they were first developed and before becoming process superintendent of the Baltimore plant, he was in charge of a 25,000-bbl catalytic cracking unit, one of the first three built. He later was placed in charge of all high-octane facilities at the Baltimore plant.

Gunter also headed the Baltimore staff of Labor Relations and further training of all employees in the operation of new equipment and served in this capacity until 1947.



General view of Cushing, Oklahoma, station.

Sinclair's "Big Inch" System in Operation

Line from Cushing to East Chicago supplies refineries in Middle West with increased volume of crude oil

FRANK H. LOVE

Map showing route of Sinclair's new line in relation to other company lines.

SINCLAIR Pipe Line Company's new "Big Inch," now in operation, constitutes an important addition to the ever-growing number of large diameter pipe lines used for crude oil transportation. This system, extending from Cushing, Oklahoma, to East Chicago, Indiana, in the planning stages was to be an 18-in. carrier but wound up as a combination 22 and 24-in. line at PAD's request because of the need for greater crude oil supplies to the middlewest refining area. The new system replaces multiple lines between the same points.

The "Big-Inch" consists of 670 miles of pipe, 330 miles of 24-in. between Cushing and Key Station at Salisbury, Missouri, and 340 miles of 22-in. from that point to its terminus at East Chicago. Stations have been constructed at Cushing, Cobb (near Caney, Kansas), Humboldt, Kansas, Gunn (near Harrisonville, Missouri), Key (near Salisbury, Missouri), Quincy, Illinois, and Flanagan (near Pontiac, Illinois). These seven stations provide a designed throughput capacity of 280,000 bbl a day for the 24-in. portion of the system and 150,000 bbl a day for the 22-in. Within the next year an additional station will be placed in operation according to present plans, which will increase the capacity on the 22-in. section of the line to 210,000 bbl a day. This station will be at Forest, Illinois, between the Quincy and Flanagan stations.

The new system serves Sinclair's East Chicago and Wood River refineries, the latter by means of a connection with the Platte Pipe Line at Salisbury, Missouri. Other eastern refineries are served by means of a connection with the Buckeye Pipe Line Company at Griffith, Indiana.

Oil is taken into the system at Cushing, Cobb, and Humboldt. Crude originating in West Texas, North Texas, and South Oklahoma fields enters the new line at Cushing. Oil from north Oklahoma and southeast Kansas is injected at Cobb station, and that from west Kansas enters the line at Humboldt station.

The line is being operated at a pressure of approximately 900 psi and as a closed system. Stations are of the semi-automatic type.

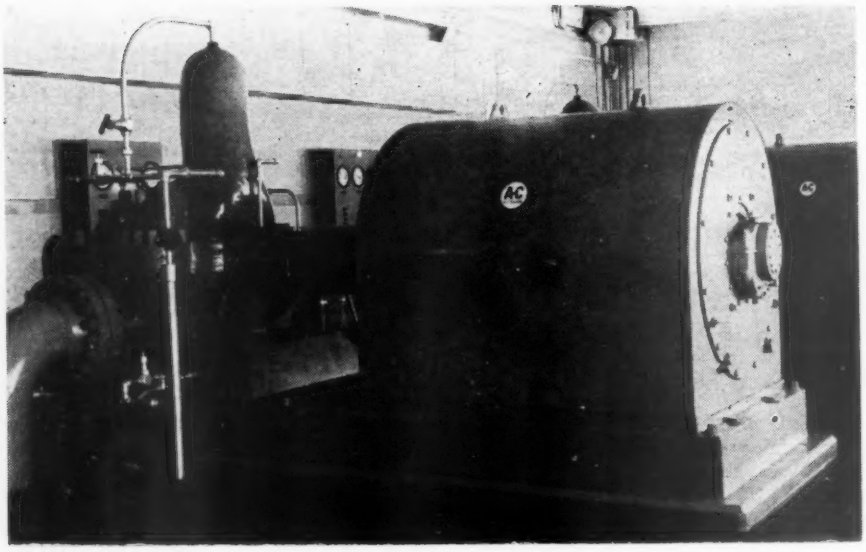
Because of greater capacity on the initial portion of the line, the first four stations have larger pumping equipment commensurate with this requirement. These stations have three 14-in., 2-stage centrifugal pumps driven by 1750-hp, 1800-rpm, 2300-volt, 3-phase motors, and one 14-in. single-stage pump driven by a 900-hp, 1800-rpm, 2300-volt, 3-phase motor. The three stations on the 22-in. section of the system have three 14-in., two-stage pumps driven by 1250-hp, 1800-rpm, 2300-volt, 3-phase motors, and one 14-in. single-stage pump driven by a 600-hp, 1800-rpm, 2300-volt motor.

Motors are of the enclosed forced-ventilated squirrel cage induction type, and meet all specifications for operation in hazardous areas. Ventilation is provided by individual blowers driven by 440-volt, 3-phase motors, controlled from a load center in the building. Across-the-line, or full voltage, motor starting is utilized.

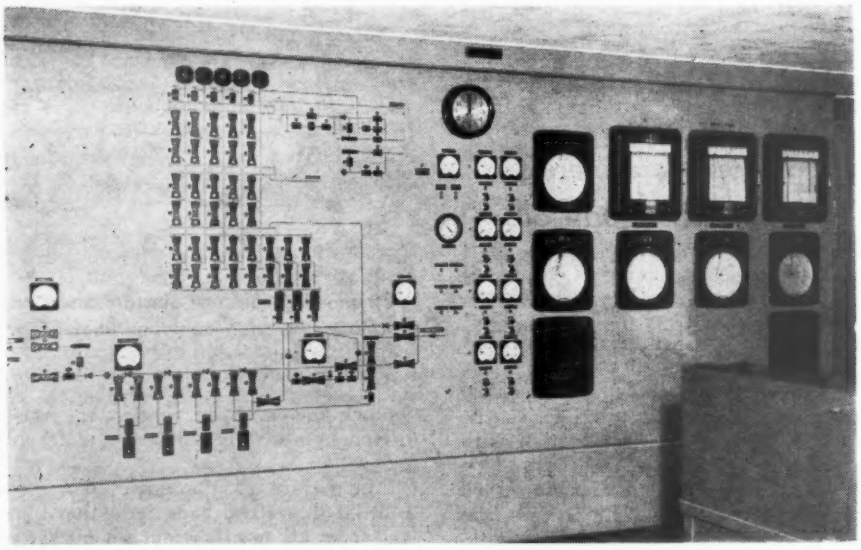
Being a closed system, tankage is provided only at injection and delivery points. At Cushing station two new 150,000-bbl floating roof tanks have been added to three 120,000-bbl tanks that were holdovers from the abandoned system. A single 150,000-bbl floating roof tank will be erected at Cobb station. There are five existing 35,000-bbl tanks at this point, and the station also is connected to Broome tank farm where there are seven 80,000-bbl tanks, the latter being used for reserve tankage. Humboldt station has one new 150,000-bbl tank and eight existing 35,000-bbl tanks.

Key station marks the end of the 24-in. section and the beginning of the 22-in. It is also at this point that an interconnection has been made with the Platte system from Wyoming whereby oil can be interchanged as desirable. At present there are two new 150,000-bbl

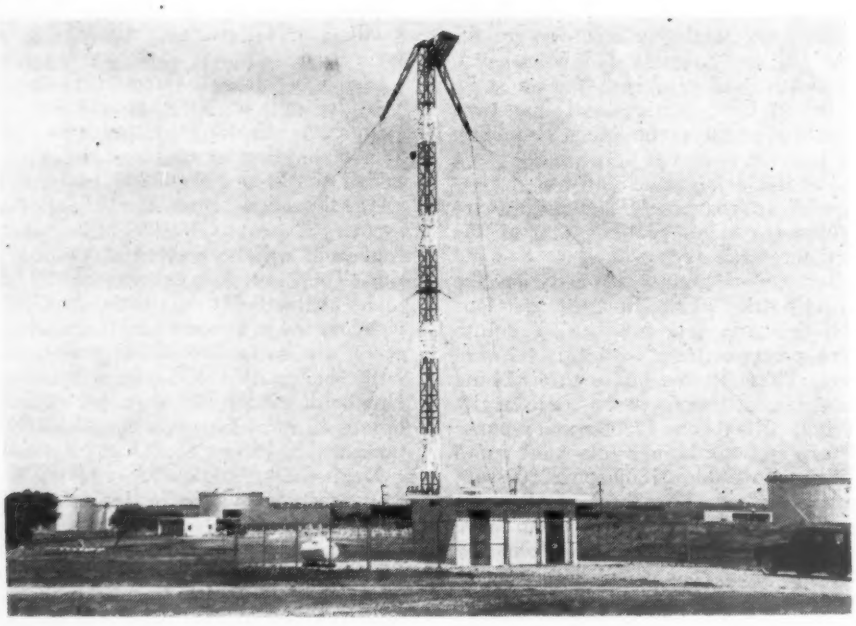
EXCLUSIVE



Prime movers are electric motors driving centrifugal pumps.



Central control panel—pulse of station.



A station on microwave system.

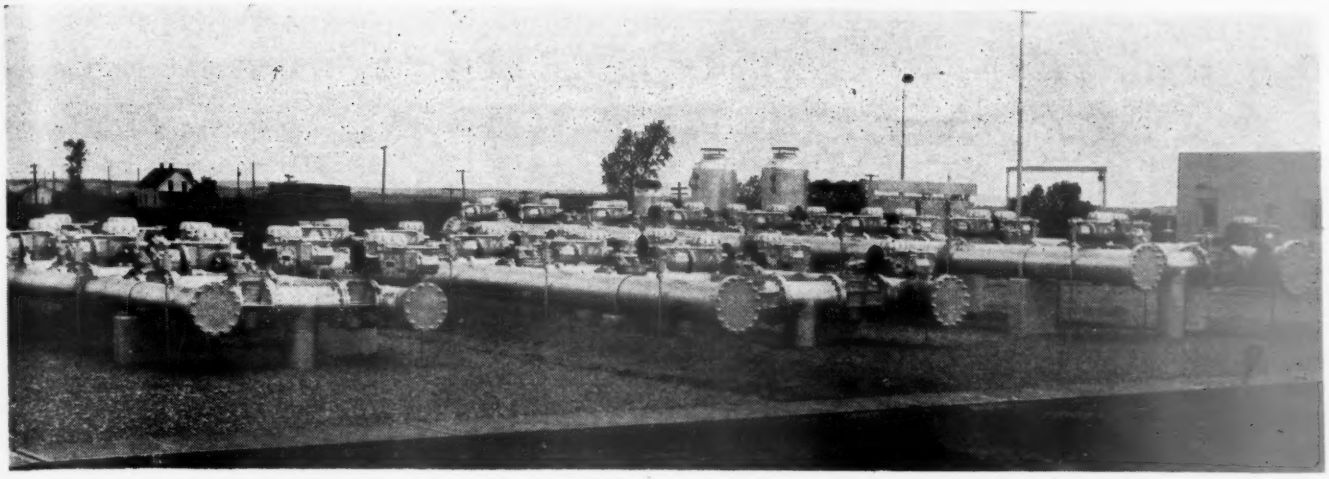
tanks, and a third under construction, which eventually will be increased to four. At Flanagan station seven new 150,000-bbl tanks have been erected. New tanks at all stations are double deck floating roof type.

Booster pumps are required in connection with tankage to pump into the suction of the mainline pumps at the proper head, and for this purpose centrifugal units driven by 440-volt, 3-phase motors are used. Electric power for the motors is brought underground by 2400-volt cables to a 2400/400-volt, 3-phase transformer, which feeds through starting equipment mounted on steel racks near the pumps. Control of the motors is from the centralized control panel in the pump building.

Centralized Control Panel

Operating personnel have complete control of the stations from a graphic centralized panel situated in the control room of the pump building. From the control room the operator can view all equipment in the pump room through a glass partition, and the panel board is the focal point for all recording, indicating, and control instruments. The panel was designed by Sinclair engineers. Mounted on the right side of the board are the mainline flowmeter, mainline controller, motor stator temperature recorder, motor and pump bearing temperature recorders, pump case temperature recorder, injection controllers, suction controller, and discharge controller. The station flow diagram is graphically laid out on the left side of the boards. Pumps, motors, valves, scraper traps, and tanks are represented by symbols. On this graphical layout valve operator control buttons and associated indicating lights, as well as pump high and low pressure indicating lights, are mounted in proper relationship. Pressures, which include incoming line, common suction, common discharge, and outgoing line, are indicated at their respective points on the diagram by small indicating instruments. The central section of the board contains main line motor control push buttons and indicating lights, motor ventilating blower control push buttons and indicating lights, individual main line pump suction pressure indicators, motor ammeters, station voltmeter, booster and auxiliary breaker indicating lights and reset buttons, panel board light test button, panel board light reset button, alarm horn reset button, sump pump indicating light, compressed air indicator, high and low voltage ground detector indicators, and station emergency shutdown push button.

The main pumping units can be started and stopped from the control panel or from a gage panel in the pump room. The start circuit is in series with a contact on the discharge balanced back-draft louver at the end of each motor ventilating duct, a contact of a purging timing relay in the blower circuit, and a contact on the discharge valve operator of each unit. A pumping unit thus will not start unless the dis-



Manifold at Cushing station.

Closeup of main station building at Cushing.

charge valve is completely closed, the blower motor has been started, which in turn closes the contact on the louver switch as a result of air flow through the duct, and the contact on the purging relay is closed. The purging relay is energized when the blower motor is started and its contacts are adjusted to close one minute later so that the blower will purge the duct and motor of any explosive vapors that may have collected while the unit was not in operation.

To put a pumping unit on the line the following procedure is observed: With the control valve in a closed position, the blower is turned on by means of a push button on the control panel. There is a time delay, then the motor can be started by means of another push button. With the motor started, the discharge valve is opened by pushing that symbol. The control valve is then adjusted so that the pump goes on the line slowly. The same sequence places each pumping unit on the line, the only difference being that after the first unit is in operation flow is controlled by the rate of flow of the first unit.

Motor Operated Valves

Motor-operated valves are controlled from two points, at the valve with a three-button station (open-stop-close) and at the centralized control panel with open-stop-close pushbuttons and indicating lights. Exceptions to this are the eight main suction and discharge valves, which have their control on the centralized control panel and on the gage panel in the pump room instead of at the valve. Certain valves that are not equipped with motor operators have micro-switches, which are installed in such a manner that an amber light on the control panel indicates when the valve is completely closed.

The system of indicating lights adopted differs from that customarily employed. The red light indicates an emergency condition, amber light a closed position, and the green light a running position. The basis for this system is the "stop" and "go" of traffic lights, and was used because it was felt that its familiarity would make it easily understood by operating personnel and thus lessen the possibility of misinterpretation.

Safety Provisions

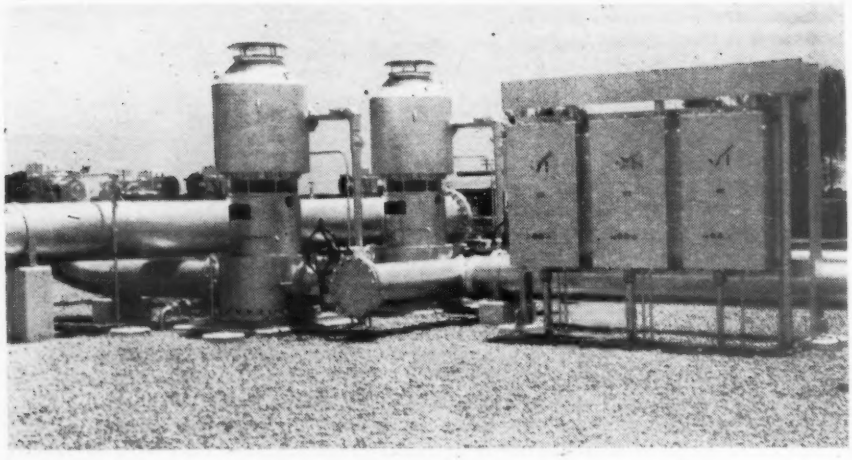
Provision has been made for complete safety of operating personnel and equipment. Relays in the switchgear will shut a pumping unit down instantaneously in event of a short circuit, or if a motor should freeze. Should the temperature in any phase reach a preset maximum, the unit will be shut down in a maximum of 48 seconds by means of resistance elements imbedded directly in the motor windings and connected to a multipoint recording instrument. An alarm is arranged to sound a horn and light an indicating light on the centralized control panel when the temperature reaches 10 deg lower than the trip temperature, which gives the operator time to correct the trouble.

Adjacent to the bearing metal in motors and pumps are placed thermocouple elements. These are connected to a multipoint recording instrument that will give an alarm in event of bearing malfunction, and 10 degrees later will shut the unit down. A light on the control panel indicates when there is trouble in a bearing and its identification can be determined from the strip chart on the recording instrument.

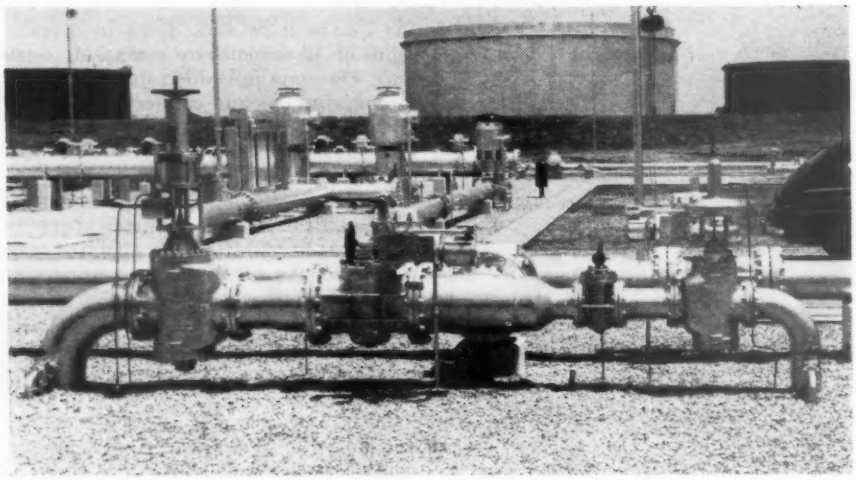
Thermocouple detector elements also are placed in the high pressure wells in the pump case. At 104 F an alarm is given and at 122 F the unit is shut down within a maximum of 8 seconds.

In the event of a single-phase condition, undervoltage, overvoltage, or phase reversal on the incoming power line, relays in the switchgear will trip out the entire station. The relays are equipped with a time-delay element to prevent unnecessary shutdowns caused by momentary fluctuations.

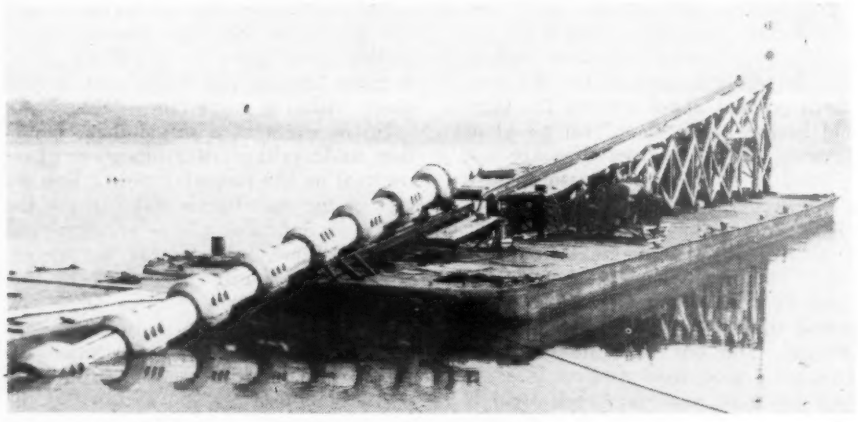
Pressure and flow indications are transmitted to the control panel by strain-gage pressure cells, utilizing electricity, so there are no oil lines in the control part of the building to create a hazard. These primary pressure detectors are connected through amplifiers and relays and provide pressure indication and over and under pressure unit trip and alarm. On the suction of each unit is an individual cell that gives low pressure protection and actuates a light on the control panel to show which unit has been tripped. One cell on the station side of the control valve, with four relays, shuts off the four units one at a time as pressure exceeds preset limits. Lights on the control panel indicate which units have been tripped. A cell on the line side of the control valve



Tank transfer pumps with their motor starters.



Control valves for batching oil.



Laying Mississippi River crossing from a ramp barge.

trips out all units simultaneously when pressure becomes excessive, with a light on the control panel for indication.

There are two locations at which the entire station can be shut down in case of an emergency, such as a fire or line break. One is by means of a button on the centralized control panel; the other is at a "break seal" type station outside the building near the gate entrance.

Protective and signal devices are wired into a common alarm circuit, and any fault will sound an alarm horn in the control room and pump room and light the associated light on the control panel. There are three push buttons in alarm system: (1) Horn reset—pushing this button silences the horn after a fault but does not affect the light; (2) light reset—pushing this button extinguishes the trouble light only if the fault has been cleared, and (3) a light test button whereby the operator can check all single action indicating lights for burnouts.

As a further safety measure, each station is provided with a head and tail gate valve, situated far enough from the station to completely isolate it in case of a fire or line break inside the station.

Substations and Switchgear

Substation equipment for Cushing, Cobb, Humboldt, and Gunn stations consists of a galvanized steel structure arranged for the termination of a 66-kv service line. The structure feeds a 6000-kva, 66,000/2400, 3-phase, 60-cycle, oil-cooled transformer, which is throat-connected to a set of 2400-volt, 3-phase, vertical lift, all-metal clad outdoor switchgear. Substation equipment for Key, Riley, and Flanagan stations are identical except that the primary voltages are 34.5 kv and the transformers are rated 5000 kva.

The outdoor switchgear has ten compartments or cubicles with a common 2400-volt, 2000-amp bus bar, and is arranged in such a manner that more cubicles may be added in event of future load requirements. In these cubicles are mounted all the equipment necessary for controlling the outgoing feeder and motor circuits, as well as all metering equipment.

Among the operating features are the rate of flow controllers provided at injection stations whereby the makeup stream can be controlled automatically. Batches can be kept segregated or various grades of oil can be injected into the flowing stream in whatever volumes are desired. The control instrument is operated from the central control panel.

Tank Gaging

At such stations as require tanks, oil levels are read remotely by means of electronic tank gages. With a single receiver in the control room the operator can take a gage on from 1 to 24 tanks. A telephone jack on the transmitter and another on the receiver are provided to operate a plug-in type sound powered telephone. Also, a high-low level alarm can be set at any desired level pumping in or out of tankage to light a light and sound an alarm when that preset level is reached.

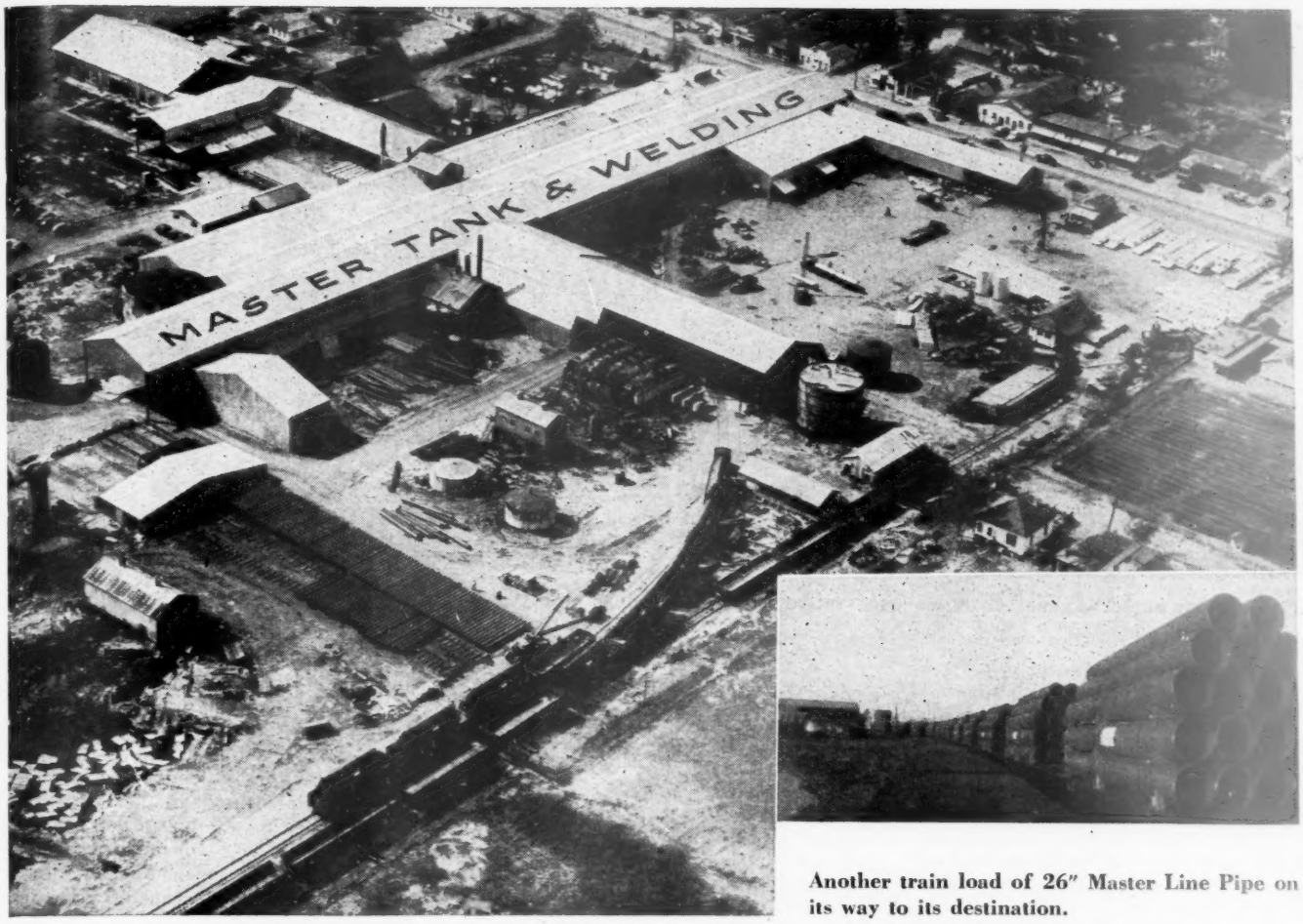
Mixers have been installed as a means of preventing sediment from accumulating in tank bottoms and connecting lines. The mixers are driven by 440-volt, 3-phase motors, which are fed from the 440-volt transformers in booster area.

Virtually all station piping is above ground, making maintenance easier and facilitating operations by enabling the operator better to identify flow through the station and understand the piping arrangement. Underground piping was coated and wrapped, bonded electrically to a grounding system, and cathodic protection applied for corrosion control. This necessitated in turn that all underground electrical conduit be insulated with a coat of primer and a coat of hot waterworks enamel to prevent excessive current drain on station rectifiers.

Station Buildings

Pump station buildings are constructed of structural steel framework,

XUM



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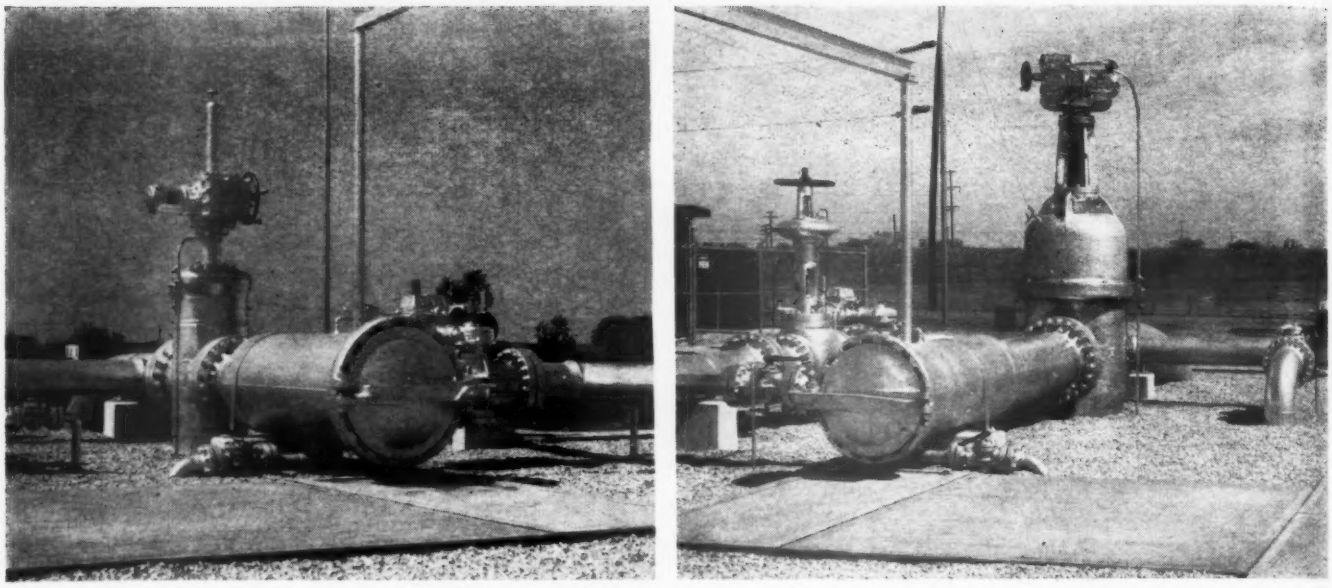


Scraper traps on suction and discharge lines, including the large valves and their motor operators, necessary to this installation.

concrete, and brick. The exterior is of face brick and architectural concrete. The roof is of monolithic poured concrete and prestressed slab. The interior of the control room is of structural glazed tile and the floor of asphalt tile. The floor of the pump room is 6-in. by 6-in. red ceramic tile. The piping side of the pump room is insulated, whereas the outer side is a metal wall with a solid line of windows.

All stations have forced air ventilation. The control room and the pump room have separate ventilating systems. Air used in the control room is recirculated, but the pump room air, because it might be contaminated, is discharged outside the station building.

In like manner, the pump room and control room have separate systems. The heating equipment consists of 240-kw blower type electric heaters thermostatically controlled.

Control contactors for the heaters are mounted in the load center.

Line Construction

The Big Inch system was constructed of X-52 line pipe having a minimum yield strength of 52,000 psi. On the discharge side of stations line pipe having a wall thickness of 11/32 in. was used. The distance from each station that this thicker walled pipe was used varies from 27 to 52 miles. The balance of the line pipe, except that used in river crossings, has a wall thickness of 9/32 in. Weight of the 24-in. pipe having 11/32-in. wall thickness is 86.85 lb per foot, and the lighter 24-in. pipe weighs 71.25 lb per foot. River crossing pipe has a wall thickness of ½ in. (X-42) and a minimum yield of 42,000 psi. The weight, however, is 125.49 lb per ft for the 24-in. pipe and 114.81 lb per ft for 22-in.

Customary construction procedures were employed for the most part. In general the pipe was given a 22-in. cover. Some ditches and gulleys were spanned either by arching the pipe or carrying it on welded A-frame supports. One of the principal construction obstacles was the amount of rock encountered. Due to the depth of the ditch this ran to greater volume than had been anticipated.

The last 12 miles of the 22-in., that through the thickly populated East Chicago area, presented another problem. The presence of water at a depth varying from 2 in. to 24 in. made it necessary to dewater by means of sand points before ditch could be made. Also in this area there were numerous street, highway, and railroad crossings, which had to be cased, as well as sewers, drains, gas and water lines, underground cables, etc. that had to be considered in laying the pipe.

Pipe Protection

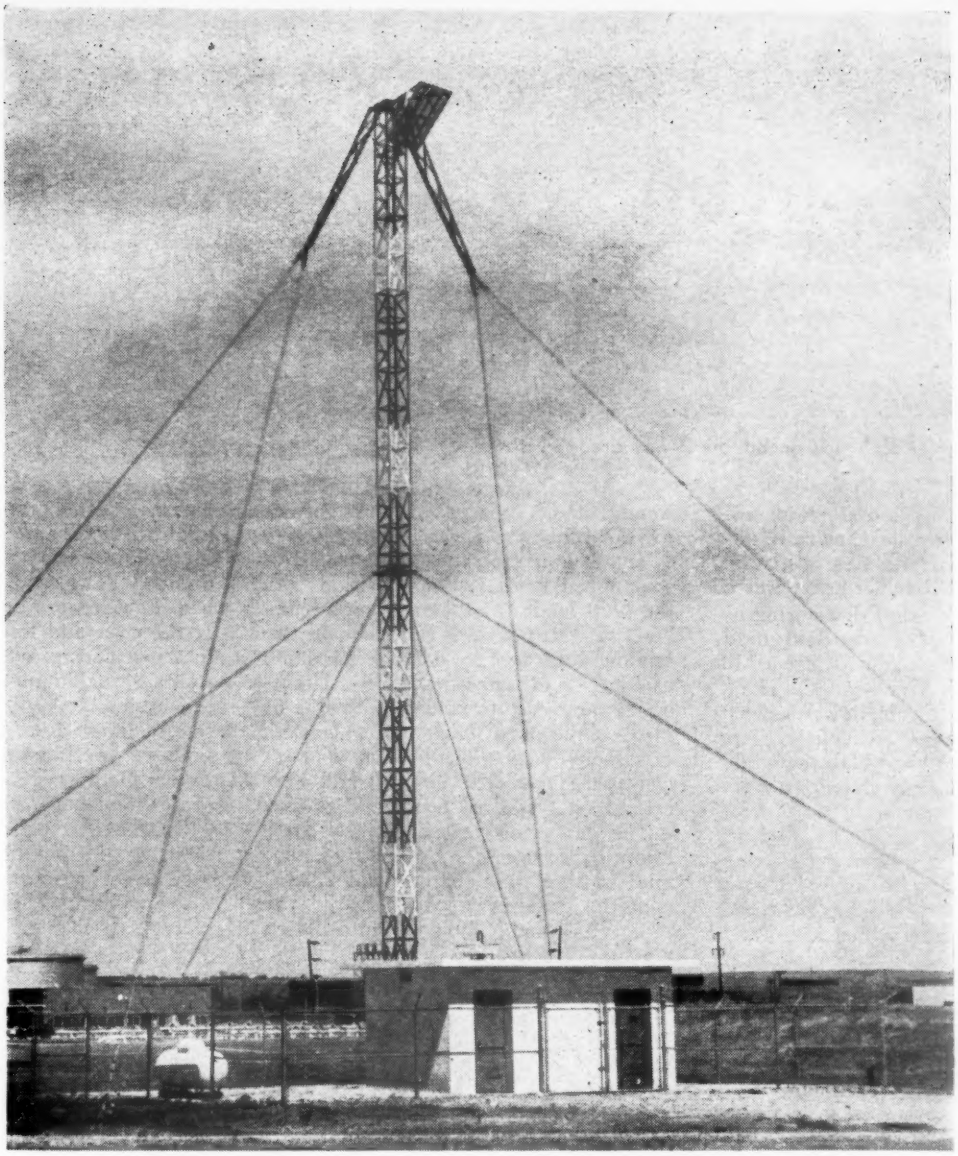
Pipe protection was provided by the application of hot coal tar enamel to a minimum thickness of 3/32, in., glass fiber wrap, and kraft paper for the main line. River crossing pipe was given a double coating. As additional protection use was made of rock shield under river clamps, in certain rocky areas to avoid damage from backfill, and at gravel road crossings that were not cased.

All welds on river crossings were X-rayed for quality and on the mainline 10 per cent were so inspected. It is noteworthy that only one weld made by a contractor showed defectiveness and that was a small pin hole.

Testing for the most part was with water. The 11/32-in. pipe on the discharge side of stations was tested to a pressure of 900 psi. The 9/32-in. wall pipe was given an 800 psi water test. River crossing pipe was tested to 1000 psi. Sections between the three stations in Illinois and Indiana were tested with air to 115 psi due to cold weather, which would have frozen the water in the line had that method been used. A hydraulic test was then applied to these sections after line fill using the oil for test.

One of the most unusual features was the great number of river crossings that were made. In all they numbered 26, of

Cimarron River was dewatered by sandpointing before crossing was laid.



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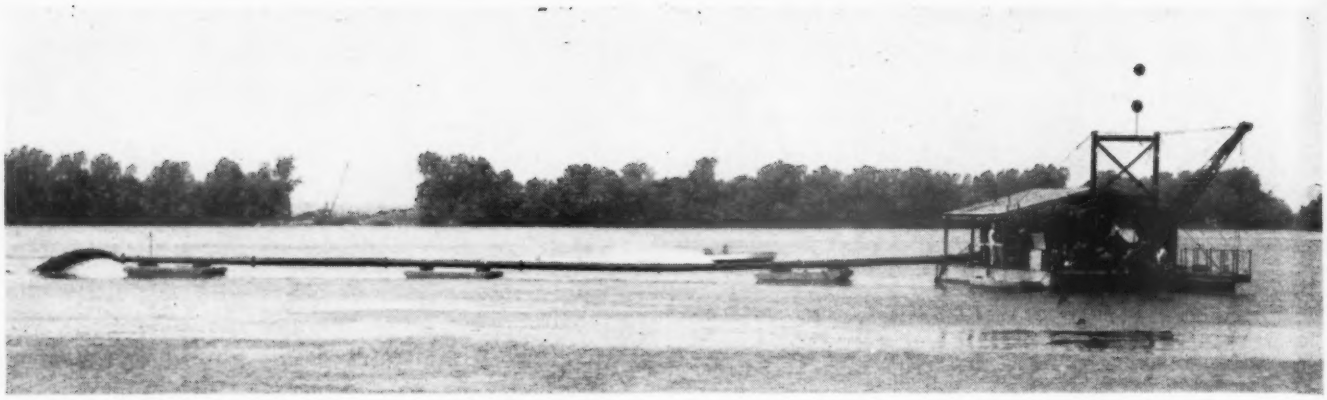

After Mississippi River pipe was on bottom it was dredged down to specified depth.

which five were classified as major rivers. The latter were the Cimarron, Arkansas, Missouri, Mississippi, and Illinois. Cimarron River crossing was a dewatering project. After dewatering by sandpointing the pipe was laid in a conventional manner at a depth of 10 to 12 ft below the river bed. The channel itself was 850 ft wide, however, 2000 ft of river pipe was used including approaches. Concrete river clamps weighing 5373 lb each were attached to the pipe at 20-ft intervals.

The Arkansas River pipe, 1200 ft in length, was floated in as a single string and dredged to depth. The overall length including approaches was 2600 ft. River clamps were of the same kind and weight, and were spaced the same, as for the Cimarron River.

The channel of the Missouri River was approximately 1400 ft wide with the total length of the river pipe being 2400 ft. The pipe was pulled in in two sections and dredged down to a depth of 7 ft. Due to danger of the river changing its course, approximately 1000 ft of pipe on the north bank had to be laid extremely deep. The concrete river clamps weighed 2187 lb each and were spaced on 6-ft 8-in. centers.

The only river crossing laid from a ramp barge was the Mississippi. The total width of this crossing was 7200 ft with the channel proper 3400 ft. The pipe was double-jointed into 80-ft lengths, coated, wrapped, and clamps applied, then hauled to the ramp barge for welding into the line. It was then dredged down to 5 ft below the river bed. Levees were crossed on both sides of the river and line pipe was enclosed in 26-in. casing, closed at the ends by welding. Baffle plates were welded to the casing at right angles to prevent small animals from burrowing along the pipe, as well as to prevent seepage. These plates were spaced at intervals of approximately 15 ft.

On the east side of the Mississippi River at the point where the crossing was made is rich farm land underlain with quicksand. There is a constant seepage from the river eastward and

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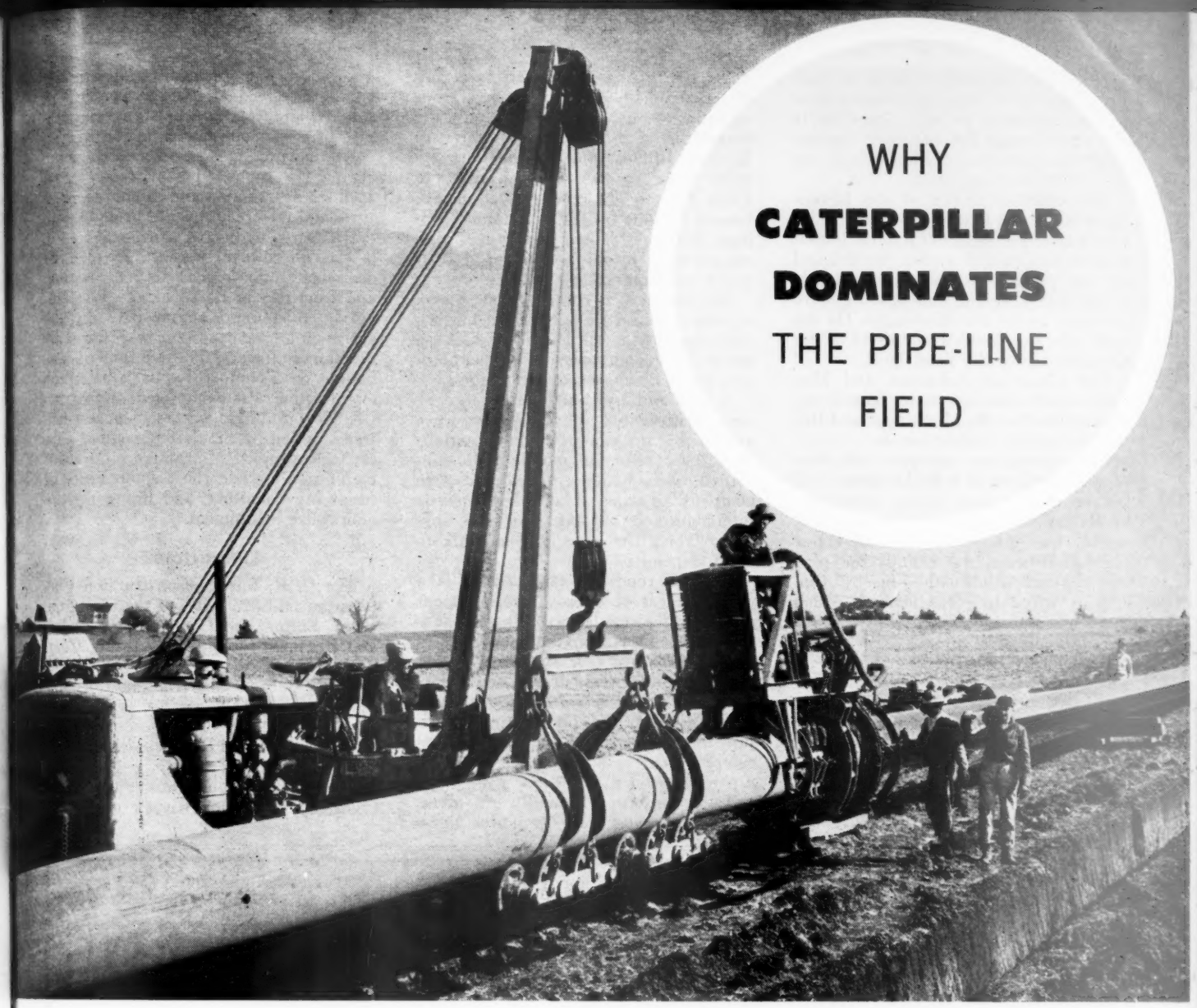

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occasionally sufficient pressure is built up to cause sand boils. As a consequence it was necessary to apply weights to the pipe through the east river bottom. The west side consists of clay soil and no clamps were required.

The channel proper of the Illinois River was 1600 ft wide and total width of the river section 2700 ft. The 1600-ft section was pulled across the channel in one piece and dredged to depth. River clamp weight and spacing were the same as for the Mississippi. On the west side the levee was crossed at an elevation above the flood level.

The Cimarron, Arkansas, and Missouri river crossings were bowed upstream, whereas the Mississippi and Illinois were laid straight across.

Extra protection was given all river pipe in the form of a double coating of hot enamel coating, glass wrap, and kraft paper. Further, 3/16-in. rock shield was placed under the river clamps. Between the clamps the pipe was covered solid with 1-in. by 4-in. slatting wired in place beneath which there was rock shield.

Microwave

A microwave system has been provided that supplies approximately 9000 circuit miles of voice channels, which are utilized for voice, teletype, control, and telemetering for the new crude oil line, as well as for the company's products pipe line system. The distance from Cushing to East Chicago is 856 beam miles and this has necessitated the construction of 40 repeater stations. Hops or paths average 22 miles in length, the longest being 35.9 miles from Norris to Morton, Illinois, and the shortest 4.5 miles from Independence, Kansas, to Table Mound. The repeater stations are housed in 20-ft by 12-ft concrete buildings. Single structure guyed steel towers are used, being a minimum of 70 ft and a maximum of 240 ft high.

Independence is control point. Alarm signals received there indicate various discrepancies at 40 locations, such as power failure, microwave equipment failure, top and side tower light failure.

A VHF radio system (station to car) was incorporated into the microwave system by installing 12 base stations of 250-watt size, 50 mobile radios installed in company vehicles, and 6 in company airplanes. The VHF system is interconnected so that personnel anywhere along the pipe line can talk to the Independence office.

At each repeater station there is a duplicate set of microwave equipment and when the regular set fails the standby equipment cuts in automatically to provide continuity of service. Another feature is an engine-driven emergency power plant at each repeater station. This unit is fueled by propane, which provides ease of starting, and is considered lower in maintenance cost over a period of time.

Tower locations normally are along accessible roads close to power lines. The equipment room is automatically ventilated by temperature control in summer and kept at a constant temperature by a propane heater in the winter.

All dispatching is performed from the company's Independence office. From each station, suction and discharge pressure, and flow readings are brought into the dispatching board at this point.

The microwave system provides 24 channels from Cushing to Key station, and from Key to East Chicago 12 channels. The general engineering on the entire microwave system was done by Sinclair engineers. The equipment was bought on a competitive basis after the engineering was completed. Construction of buildings, towers, fences, etc., was handled by Sinclair personnel as a separate project. Microwave equipment manufacturers had the responsibility of supplying installing, and lining up the microwave equipment.

Contractors

The O. R. Burden Construction Corporation laid 325 miles of the pipe line, R. H. Fulton and Company 180 miles, and Britton Brothers Contracting Company 165 miles.

O. R. Burden Construction Corporation installed the Cimarron and Arkansas river crossings, C. S. Foreman Company, the Missouri River crossing, Pentzien, Incorporated, the Mississippi River crossing and Missouri Valley Dredging Company, the Illinois River crossing.

* * *

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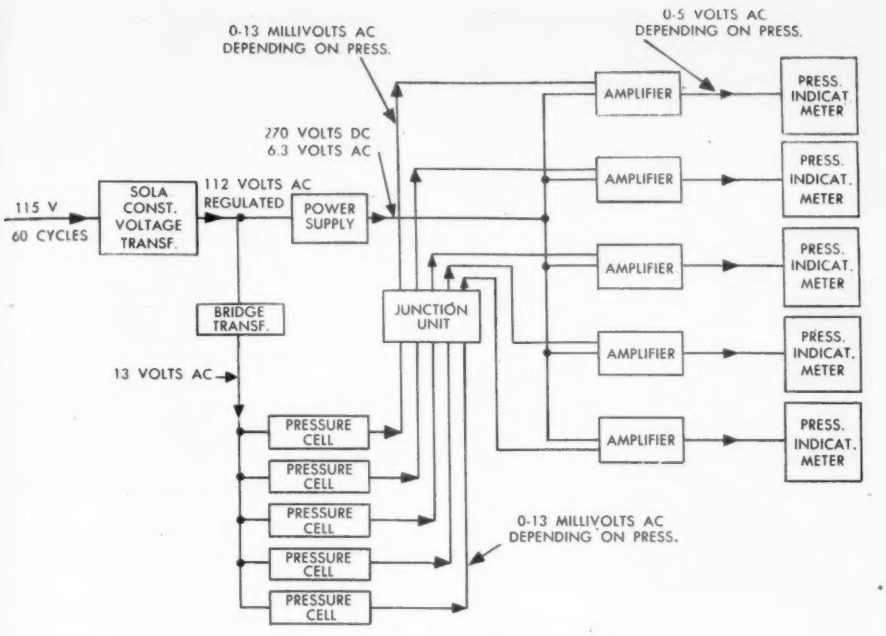


FIG. 1. Block diagram of the pressure measuring system.

Maintenance Experiences With Electrical Pressure Gages*

Transmitting remote pressure reading to central control point has proved stable, accurate, and trouble-free

WILLIAM W. HOLT, JR.

EARLY in 1948, Plantation Pipe Line Company made a survey of the available types of electrical pressure pickups that convert hydraulic pressures into electrical quantities. Various types were investigated. The strain gage pressure cell was selected because of its accuracy, simplicity, and dependability. In a series of pressure surge measurements conducted under another project, this cell had established its ruggedness and capability of withstanding severe shock overloads.

In April, 1950, a complete experimental electrical pressure gage instrumentation was installed at one of Plantation's main line stations. This system consisted of a common power supply, five pressure cells, and five indicating meters. The cells were locally mounted at the desired pressure points within the pump station. Application of the strain gage pressure cells and associated circuits for this installation was designed by the manufacturer of the pressure cells in accordance with Plantation's general specifications.

The central power supply is an electronic voltage-regulated rectifier that supplied d-c voltage to the cells. Output of the strain gage bridge at rated pressure is one millivolt for each volt of input. No amplification was used because the meters were of the sensitive galvanometer type, which produced a full scale reading with but 8 mv.

In one and one-half years' operation this system required the replacement of vacuum tubes at a cost of less than $15. This replacement was made by station personnel. A complete dead weight calibration at the end of the test showed that the entire system's accuracy was well within 1 per cent.

Operational Installation

Although the service life of the experimental instrumentation as a whole had not been determined, there was ample information on the component parts to indicate that an economical life could be expected. With this and the experimental data weighed against troubles experienced with liquid lines and bourdon tubes, it was decided to incorporate a redesigned system in Plantation's recent expansion program. In adapting the system to the enlarged stations, experience indicated that some changes and improvements were desirable. The two complaints received from operating personnel were that meters would not respond rapidly enough to pressure changes and that their readability was poor.

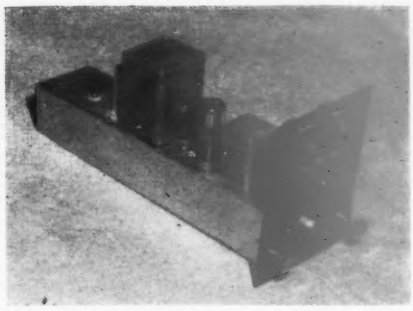


FIG. 2. Amplifier chassis.

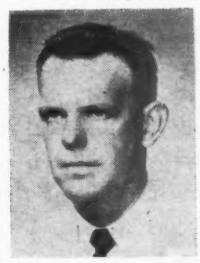
The main difference between the new system and the experimental is that it is a-c instead of d-c operation and that an individual amplifier increases the power output of each pressure cell to its corresponding meter. All vacuum tubes in the power supply are eliminated. The amplifier in each pressure channel permits the use of a more rugged meter with better readability, quick response, and one that can be mounted in a horizontal position.

Fig. 1 shows a block diagram of the pressure measuring system. The 115-v, 60-cycle a-c power is supplied at the left to the primary of a constant voltage transformer. A regulated 112 a-c voltage is then applied to the main power supply. It is of drawer-type, plug-in construction and contains no vacuum tubes. The component parts are a transformer, selenium rectifiers, and filter circuit that supplies d-c plate voltage for the tubes in the amplifiers. Filament voltage is also supplied by this unit. A bridge transformer with an output of 13 v a-c supplies the pressure cells.

Output of the cells then passes through the junction unit and to the amplifiers shown in Fig. 2. These are of the two-stage type using a 5691 Red Line tube that has an expected filament life of 10,000 hours. Amplifiers employ high degenerative feedback for stabil-

The Author

William W. Holt, Jr., is in charge of the technology section of Plantation Pipe Line Company's engineering department. Holt was graduated from Georgia Institute of Technology, Atlanta, joining Plantation in 1947. His duties cover supervision and direction of research projects, design of experimental equipment for products pipe line application, study of operating techniques and methods, and recommendations for improvement.



*Presented before the American Petroleum Institute Products Pipe Line Technology Conference, Kansas City, Missouri, April 20-22, 1953.

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ity and therefore limit signal amplification to the 5 volts necessary to drive the indicating meter to full scale.

The indicating meters are dial type having approximately 270-deg needle swing. They are standard 5-v a-c rectifier type voltmeters and are connected directly to the output of the amplifiers. These are shown in Fig. 3.

Fig. 4 shows the installation of the console in a standard switchgear cabinet. From top to bottom are the amplifiers, storage compartment, power supply, junction unit, and the blower. All parts are removable for service or replacement from the front. A spare amplifier is included in the amplifier section at the top and can be used with cells of any pressure range.

Routine Maintenance

Until sufficient experience has been obtained to warrant a change, Plantation's electrical crews will perform a complete dead weight calibration of all pressure channels annually. This procedure requires three men working approximately one-half day to complete one station and includes the following:

1. Turn the selector switches on all amplifiers to the "Zero" position and then set the screw driver adjustments on the front of the indicating meters so that the pointers are at zero.

2. Turn the amplifier selector switches to "Operate" position. Remove all pressure from the cells. Adjust the resistance balance and capacity balance controls on the amplifier for a minimum reading. Adjust one at a time and repeat until the meter pointers are at the minimum, which should be the same as the mechanical zero of the meters.

With the 500-psi meters the resistance balance is adjusted for a minimum and then capacity balance is adjusted until the meter pointers are at zero.

3. With a dead weight tester connected to the pressure cell, apply a pressure approximately equal to 0.7 of its capacity. This point is marked in red on each meter scale. Adjust the gain control at the top rear of the amplifier until the meter pointer is at the red line.

4. Set the selector switch to "Calibrate" and turn the calibration adjustment until the meter pointer is at the red line. This provides a reference signal that can be used for a calibration check at any time.

The following electrical calibration is normally performed by station personnel once each week and requires but a few minutes:

1. Set all amplifier selector switches to "Zero" and adjust the mechanical zero of the meters.

2. Turn the selector switch to the "Calibrate" position. If any meter pointer does not come to its long red line, adjust the fine gain control under the control desk.

Problems Encountered

Fig. 5 shows the installation of pressure cells. In assembly many of these cells were damaged by rough and careless handling. Finally a 1-in. diam pipe nipple, cut to the same length as the cell, was used in making up all piping

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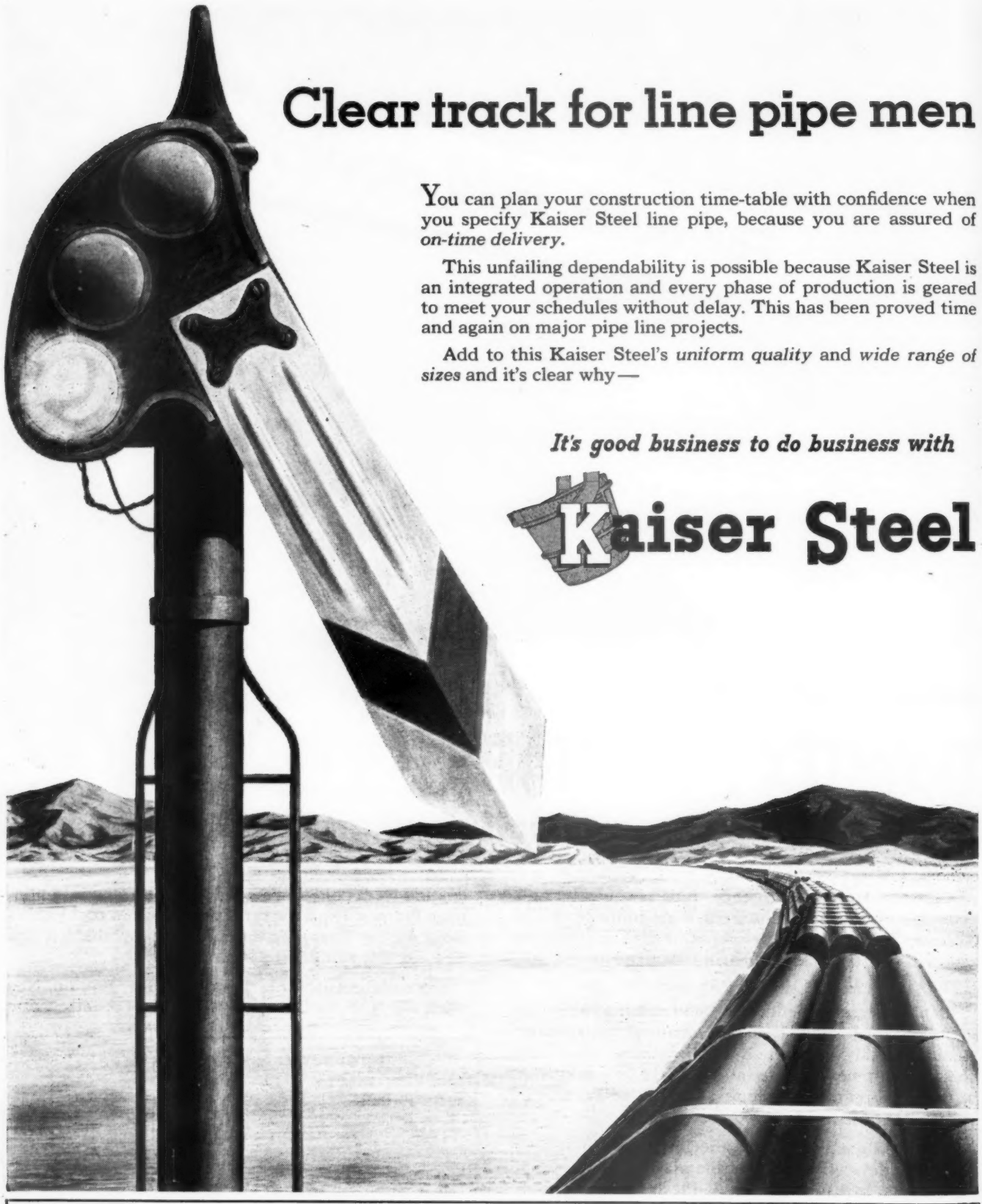

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Electric Resistance Weld—Plain End	5⅝" to 12¾" O.D.	Up to 55'	.188" to .375"	Fontana, Calif.
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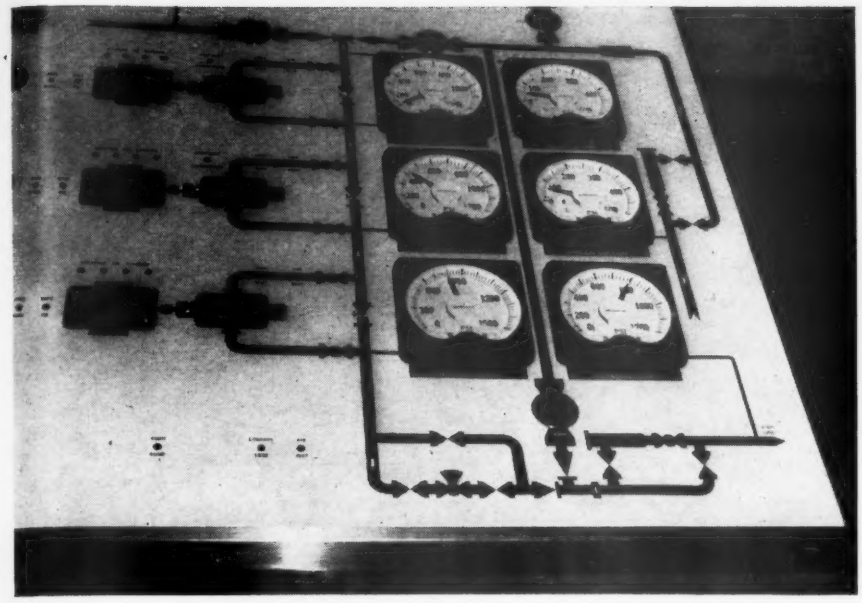


FIG. 3. Pressure indicating meters.

and conduit fittings, and the cell was installed later.

Plantation used 1-in. diam pipe fittings on all liquid lines to the pressure cells. This size was not difficult to make up because of the short nipples but required excessive pumping with the dead weight tester in order to build up test pressures. One-inch fittings from the main line through the valve and then ½-in. fittings to the pressure cell would reduce the time necessary for calibration and put less strain on the cells.

Two cell failures were traced directly to mechanical vibration. This was corrected by a change in nipple length and a resulting change in the natural frequency of the cell assembly. No further failures of this nature have been reported.

Pressure cells should be mounted vertically with the liquid end pointing down. There have been several cases when dirt has caked into the liquid chamber and caused the cell to malfunction. Also water collects in this area and freezing renders the cell inoperative.

Conduit settling has damaged several cells. A more substantial underground foundation readily eliminated this situation.

The valves off the main line should provide a tight seal between the line and the pressure cell; otherwise a steady test pressure cannot be maintained. This will seriously affect the accuracy of the system. Because of the dirty condition of a new pipe line, some trouble has been experienced with these valves.

Blowers, mounted under the amplifiers for cooling purposes, direct dust up into the junction unit and the amplifiers. Probably a dust-stop on the intake would solve this problem. There has not been any difficulty from this condition.

Some meters, whose gaskets had been damaged would stick because of accumulated dust. Proper cleaning and sealing return them to good working order. No meter failures have been experienced.

After putting the system into operation, the most serious problem was encountered with operators. Their natural curiosity about new equipment and resultant "tinkering" required the recalibration of many channels.

Conclusions

After one year's operation these conclusions have been reached:

Pressure cells, when subjected to normal operating service, are trouble-free. Physical damage is readily and economically repaired. None has been damaged so completely as to require replacement. Many cells are subjected to pressures of 150 per cent of their normal rating without any apparent damage.

During the first year's operation, there has not been a single failure among the 164 amplifiers and tubes used on the entire pipe line. This fact is impressive even though the expected vacuum tube life was 10,000 hours.

The constant voltage transformers and selenium rectifiers have been completely trouble-free.

An excellent training program, initiated during construction for the electrical crews, has produced personnel well qualified in the maintenance of the pressure measuring system. The instructions of station operators in the principles and care of the system has eliminated call-outs of the electricians, and repairs are made during their normal preventive maintenance visits.

Overall this electrical instrumentation has established itself as a very stable, accurate, and trouble-free method of transmitting remote pressure readings to a central control point. It is well liked by operating personnel who repeatedly point out the lack of minor needle fluctuations and the excellent readibility of the meters. * * *

FIG. 4. Amplifier console.

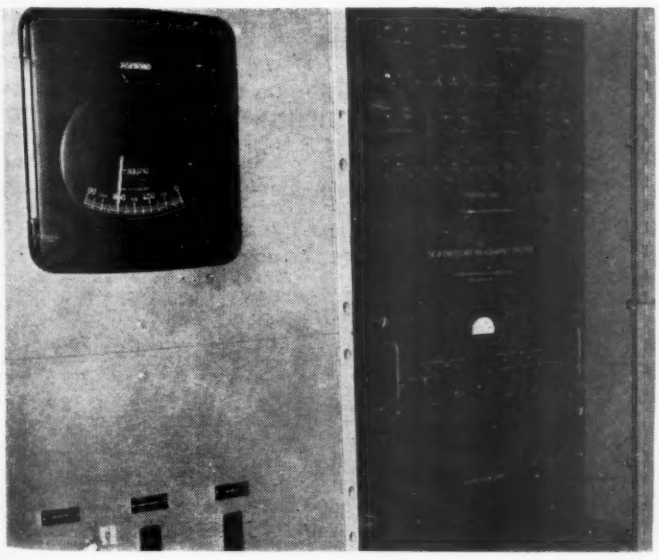
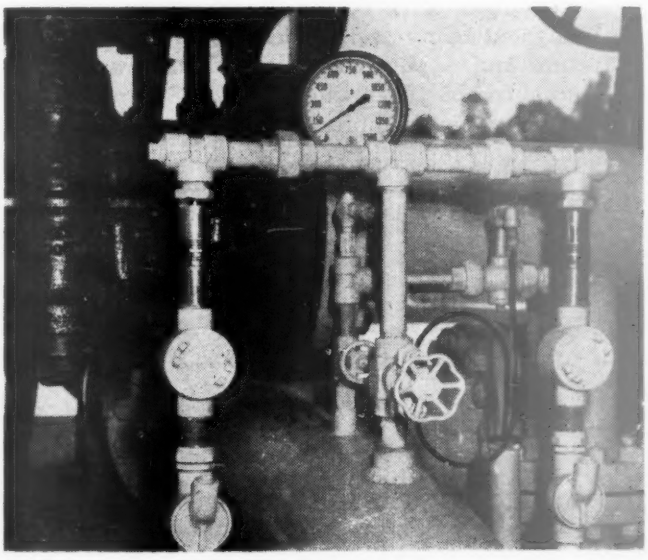
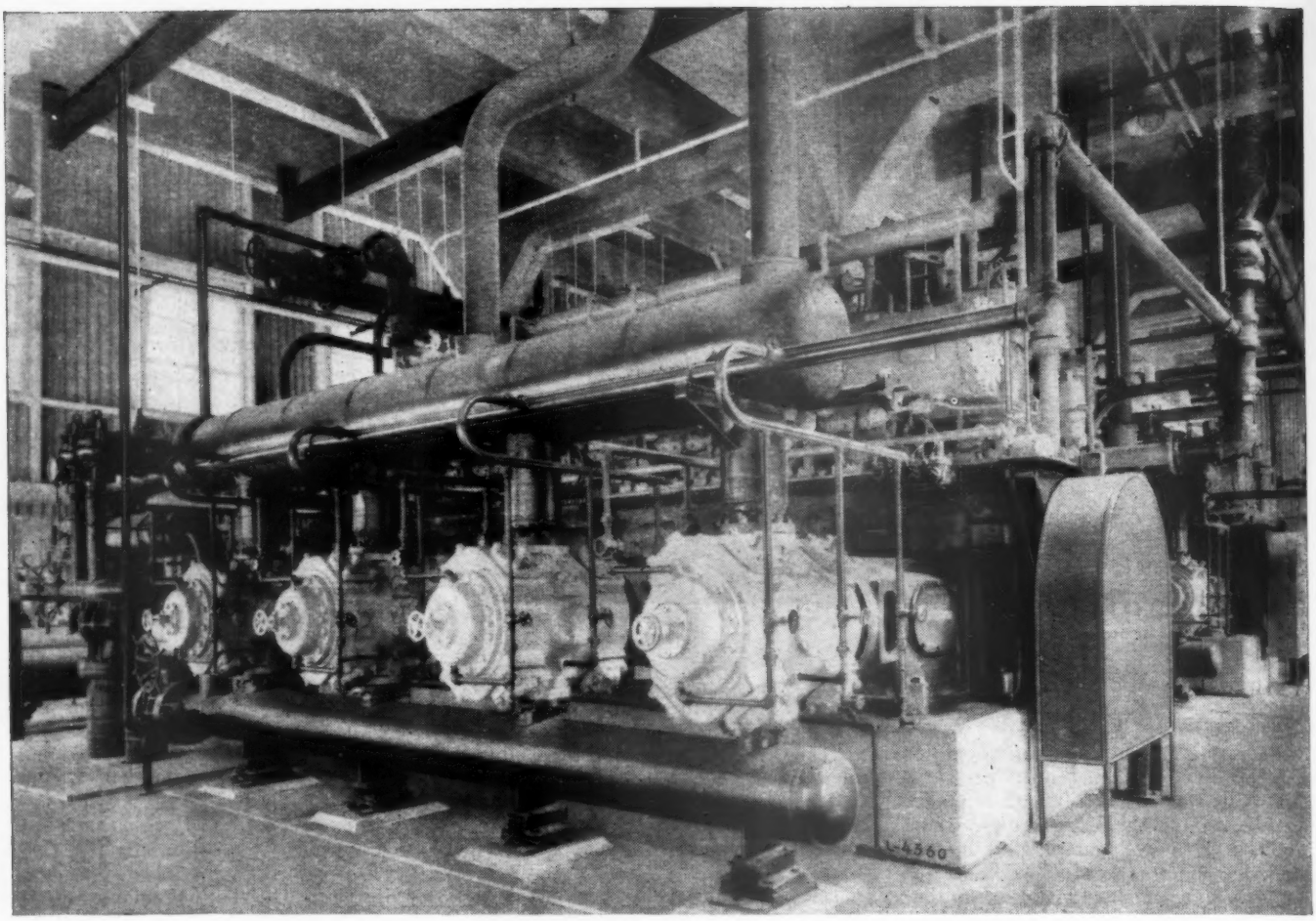


FIG. 5. Pressure cell installation.





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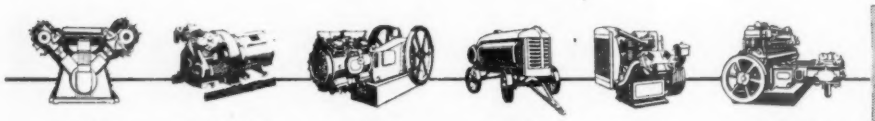

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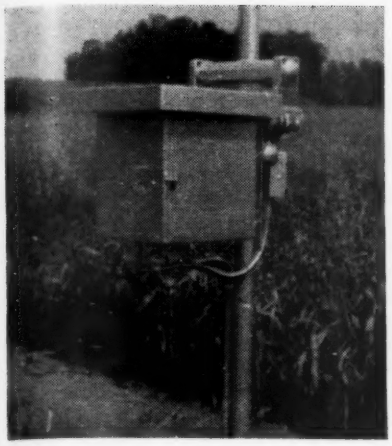

FIG. 1. Single post support is is provided for small rectifier unit.

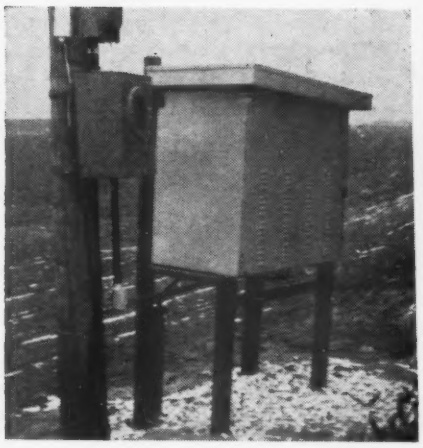

FIG. 2. Support for larger rectifier unit.

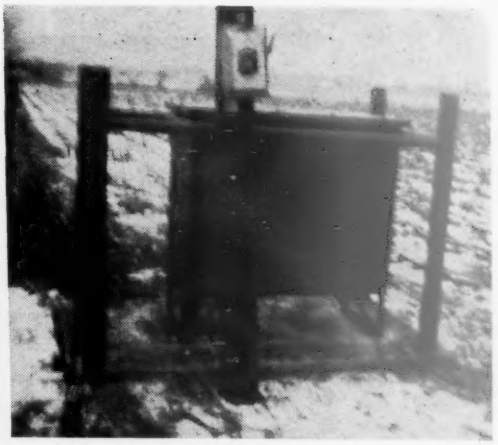

FIG. 3. Oil-immersed rectifier supported on concrete platform.

Operation and Maintenance of Rectifiers

Many factors enter into selection, installation, and maintenance of rectifier units for cathodic protection

J. C. BERRINGER

PANHANDLE Eastern Pipe Line Company's experience with cathodic units began in 1937 when a windmill generator was installed to provide a source of direct current for cathodic protection. At that time, and for the next five years, most of the cathodic units were windmill generators as there were few locations where electric power was available.

Our first metallic rectifier was installed in 1938. This was a copper-oxide unit with forced draft for cooling as the direct-current output was 20 v and 100 amp.

As electric energy became available in more locations, use of the metallic rectifier increased as it is a more dependable and suitable source of direct current.

In 1945 we installed our first large capacity selenium rectifiers, which have normal convection cooling. We have a number of oil-immersed rectifiers; however, as operating conditions on our system permit the use of the convection cooled units, we are now installing this type.

Our first consideration on all rectifier installations is a suitable and economical source of power. A temporary unit location area is selected and preliminary arrangements are made for power. The power company requirements for service are determined and a schedule of rates obtained. A survey is then made to locate the anode system in a low resistivity soil with consideration being given to location of our structure to be protected, as well as producing a minimum of interference on other underground structures that may be in that area.

The Author

J. C. Berringer is chief corrosion engineer for Panhandle Eastern Pipe Line Company. Holder of a BS degree in electrical engineering, he joined Panhandle Eastern Pipe Line Company in 1936, and from 1943 to the present date, his entire time has been devoted to corrosion control problem of the company.

Berringer is a member of the National Association of Corrosion Engineers, American Petroleum Institute, and served on the corrosion committee of the American Gas Association.

A support must be provided for the rectifier that will permit inspection and maintenance with minimum of difficulty and also reduce the hazard of damage to the unit and appurtenant equipment from mechanical action, as well as flood conditions.

There are three standard types of supports provided for our rectifier installations, the size of the unit, as well as location, determining type to be built.

EXCLUSIVE

To reduce space requirements, a single post support, as shown in Fig. 1 is provided for the small units. A section of 4-in. pipe is used in fabricating this support, which is set in a small concrete block to a depth of approximately 3 ft and extends above the ground level a sufficient length to provide clearance for the power supply line as required by the electrical code. Conduit for the d-c leads extends from just below the rectifier and through the concrete block with a 90 deg bend so that entry of the cable is below the ground line. The conduit is anchored in the block and provides adequate protection for the d-c leads to the unit. The power supply line enters at the top of the 4-in. support through an entrance head and is then brought out of the support at the proper level for installation of the meter socket.

The support provided for the larger units in areas where there is no danger of floods is shown in Fig. 2. The legs of the support are fabricated from 4-in. pipe and extend 2 to 3 ft below the ground level. Conduit is provided on the legs of the support for the d-c leads. Fig. 3 is an oil-immersed rectifier installation where a concrete platform provides the necessary support and a fence protects the unit from external damage.

Cathodic protection is provided to 14 main line river crossings and at some of these locations, as well as other areas, flood conditions may exist. In flood areas the units are installed on elevated platforms above maximum flood level, as in

FIG. 4. Rectifier on elevated platform in flood area.

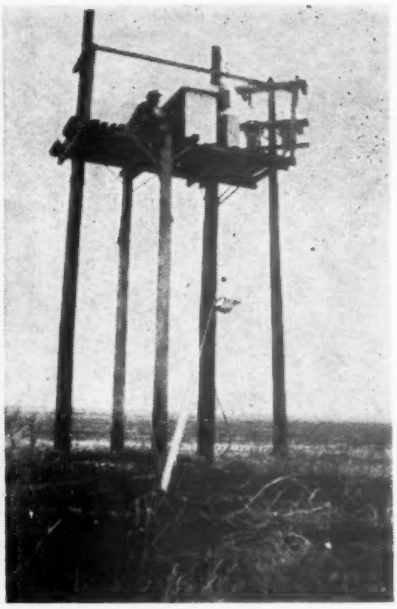

FIG. 5. A still taller platform in flood area.

Figs. 4 and 5. Guy wires are used where that additional strength is required, depending upon the height of the structure.

A careful study is made of power rates available, as these cathodic installations are considered a permanent appurtenance of the pipe line system. A small savings in the power cost per month for each unit will result in a considerable savings, due to the great number of units operating on purchased power, as well as years of service for these units.

The estimated power requirement for each installation is considered when various rate schedules are available. If 3-phase service can be supplied, it is requested for the large capacity units of 50 amps or more d-c output. The increase of approximately 20 per cent in efficiency for 3-phase units as compared to single-phase units for large capacity rectifiers will produce a definite savings in energy costs for such installations. The power costs for small units will not offset the usual additional charge made by power companies for 3-phase service.

In order to obtain maximum efficiency from rectifiers for cathodic protection, the original engineering estimate should include a rectifier that will operate above a minimum of 40 per cent of the rated voltage because the efficiency of the rectifier unit decreases rapidly when operating under this value. One of the main factors to consider in determining the size of the rectifier unit is rated current capacity, and although the decrease in efficiency is not as critical when a rectifier is operated at fractional loads above 20 per cent full load, the unit should be operated at near rated capacity to reduce cost and size of the installation.

Operating or ambient temperature limits for many of the selenium rectifier cells at maximum capacity with natural draft cooling is 35 C. For large capacity units this is more critical as temperature rise may exceed safe limits during the summer months when the unit is operating at full load. The actual temperature of the stacks and transformer may be determined quickly and accurately with the use of temperature sensitive indicators similar to a crayon. These temperature indicators are manufactured to melt at a predetermined temperature. The proper temperature crayon is selected and a mark of the crayon is made on the stacks or transformer. If the temperature for which the crayon is manufactured is exceeded, the crayon mark will melt. The use of these crayons for various temperatures will indicate if safe operating temperature is exceeded.

If temperature is excessive, ventilation and heat transfer must be improved or the load reduced to maintain a satisfactory service life for the rectifier. Various types of ventilators are now in service on our rectifier installations. Additional data will determine whether an unrestricted flow or chimney effect can be obtained to remove excessive heat and also provide protection from the weather for the operating equipment.

Corrosion control or mitigation on the pipe line system is under the superintendent of pipe lines. Pipe line employees are instructed to inspect cathodic units during their routine inspection trips over the system, as well as any time they are in the vicinity of such installations. This provides an economical method for obtaining information regarding the operation of our cathodic units and maintaining them in continuous service. Many of the units are inspected once each week, while all units are inspected at least once each month. Reports are sent to the corrosion engineers for that particular area each time a unit is inspected. Any rectifier failure or required maintenance is re-

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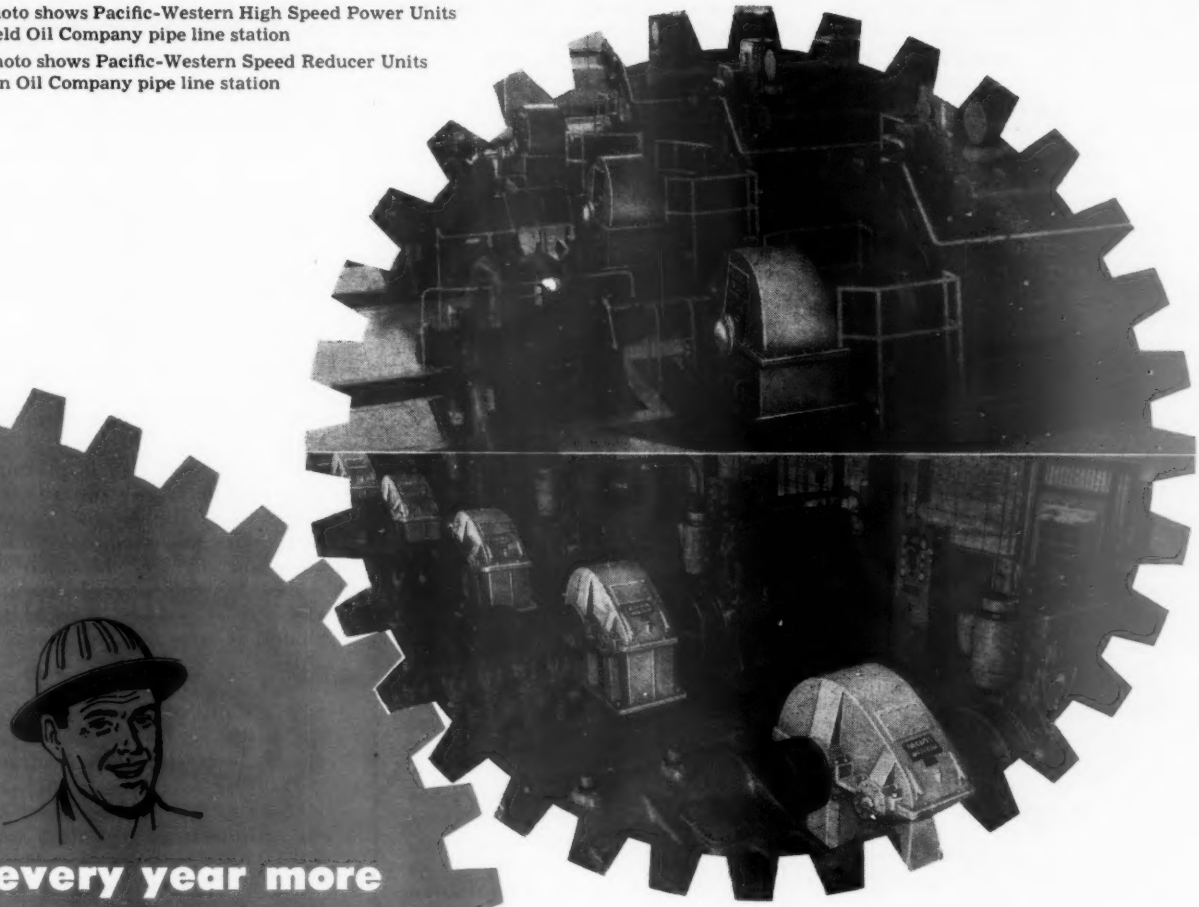
Upper photo shows Pacific-Western High Speed Power Units at Richfield Oil Company pipe line station

Lower photo shows Pacific-Western Speed Reducer Units at a Union Oil Company pipe line station



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ported by this method to the corrosion engineers. The corrosion engineers are responsible for maintaining all cathodic units in satisfactory and continuous operation. By using this procedure of inspection, rectifier "down time" for cathodic units is reduced to a minimum and continuous operation and satisfactory protection is provided at minimum cost.

The following annual test to be made by the corrosion enginers on each rectifier unit was designed to obtain information regarding individual rectifier operation and observe any changes in efficiency. An excessive decrease in efficiency under normal operating conditions between annual inspections could indicate that the aging of the rectifier cells has progressed beyond the limits of satisfactory operation and replacement is necessary.

Annual Test of Rectifiers

1. Check d-c panel meters with portable meter and correct if necessary.
2. Read a-c input to unit in volts and amperes and obtain "apparent" watts input.
3. Count the revolutions per minute of the power company wattmeter, multiply the revolutions for one minute by the factor (Kh) of the meter and then by 60 to obtain the true watts input.
4. Divide true watts input by apparent watts input to obtain power factor.
5. Divide the d-c output in watts by the true watts input (obtain from wattmeter) to obtain efficiency of unit.
6. Measure the a-c input to each group of stacks and if the reading is not within the limits for satisfactory operation check the a-c input to each stack to determine the location of excessive a-c drain.
7. Another test for stack leakage or failure is to disconnect the positive cable and operate the unit at rated d-c voltage and no load. Measure the a-c amp input from the transformer secondary to determine the quantity of leakage current. Measurement of a-c amp input to the stacks can be made with a hook-on" ammeter. The existing power company wattmeter can also be used, but this would then include all transformer losses. This reading, however, could be used to compare with previous readings taken, and an increase would indicate that additional testing is required.
8. Check all possible connections to be certain that none are loose and examine transformer and stacks for high operating temperature.
9. Any collection of foreign matter sufficient to reduce heat radiation and transfer should be removed from the stacks and transformer.
10. On all units that have a drain wire from the case to the negative terminal of the rectifier measure the d-c amp drain and include this information in the report.
11. A rectifier unit inspection form is provided to report the results of the above tests. The original is sent to the main office and a copy retained by the corrosion engineer. Included under remarks for the air-cooled units is the number of stacks, manufacture and model, or code number if this is available.

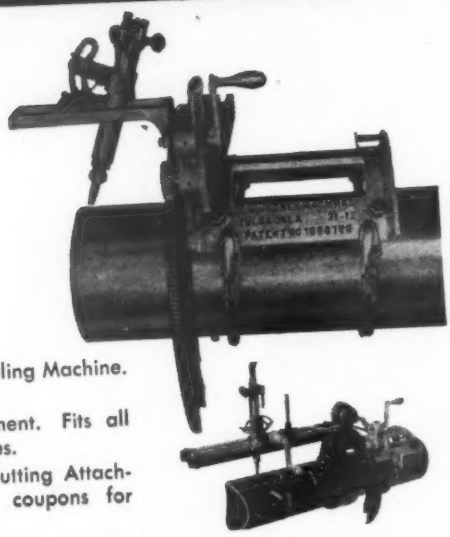
Lightning protection is provided on both the primary and secondary side of the power supply to reduce possibility of such excessive voltage surges.

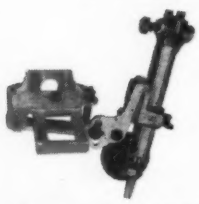
Every attempt is made to operate the rectifier within the specified limits of the manufacturer regarding output and temperature in order to reduce maintenance and obtain a satisfactory service life for the equipment. * * *

Negligence, not accidental damage, is the most frequent complaint in claims that insurance companies receive against their coverage of pipe line operations, especially construction work by contractors. Insurance in most cases doesn't cover such claims, and untold troubles and expensive claims can result by not being careful. Some states grant as high as triple damages to wronged property owners. Carelessness in leaving a gate open, using a private road without authority or violating property beyond right-of-way are among the major causes of claims. It's easier to check the limits of right-of-way and use of access roads than to pay damage claims. It's also safer.

*Mathey PIPE CUTTING AND BEVELING MACHINES

- QUICKEST IN OPERATION
  - Just slips over pipe
  - No hinges or latches to open or close
- LIGHTEST WEIGHT
- FIVE MODELS (for pipe from 4" to 36 inches)
- ECONOMICAL
- FOR RENTAL OR PURCHASE





Illustrated above: Mathey Pipe Cutting and Beveling Machine. Cuts pipe at any predetermined angle.

Illustrated left: Mathey Out-of-Round Attachment. Fits all sizes of Mathey (and Mathey-made) Machines.

Illustrated right: Mathey Shape and Coupon Cutting Attachment. For cutting pipe intersections and coupons for welding analysis.

*COMPLETE STOCKS OF PARTS FOR ALL MATHEY and MATHEY MANUFACTURED MACHINES IMMEDIATELY AVAILABLE

C. A. MATHEY MACHINE WORKS, INC.
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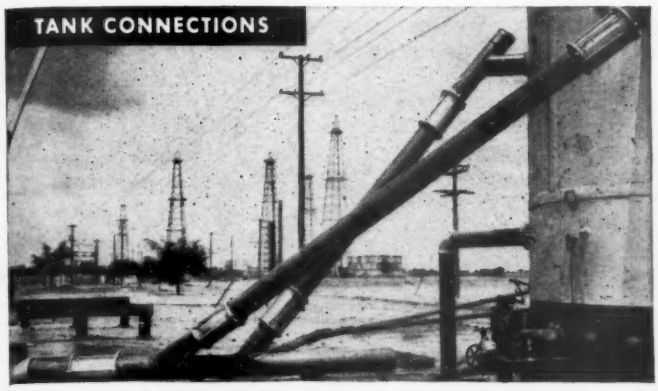
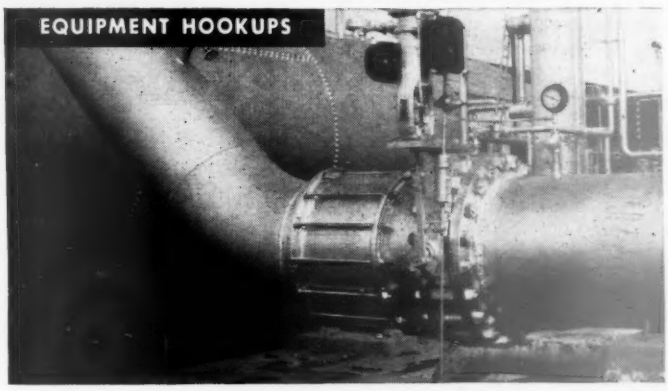
XUM

IN THE OILFIELDS . . .

the DRESSER way is *easier . . . surer!*





As an oilman, you're interested in joining pipe quickly . . . maintaining tight joints . . . making fast repairs with minimum losses and shutdowns. Using Dresser Couplings and repair products, you can do just that.

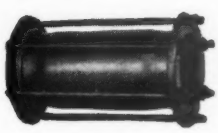
Dresser Couplings or Long Sleeves go together simply and quickly. Resilient Dresser Gaskets assure flexible joints which absorb settlement, other movement . . . on well and separator piping . . . salt-water lines . . . tank, pump, engine and compressor connections.

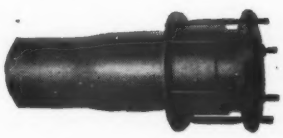
When a split, break or leaking joint occurs, Dresser Clamps and Sleeves turn an emergency into a simple repair job—completed in a matter of minutes *without shutdowns.*

You'll find there's a Dresser product for every condition and requirement affecting oilfield pipe lines, and that the DRESSER way is *always* easier, surer.

AVAILABLE AT ALL LEADING OILFIELD SUPPLY STORES

Style 38
Coupling


Style 40
Long Sleeve


Style 63
Expansion Joint

Style 39
Insulating Coupling

Style 55
Porous Weld Clamp

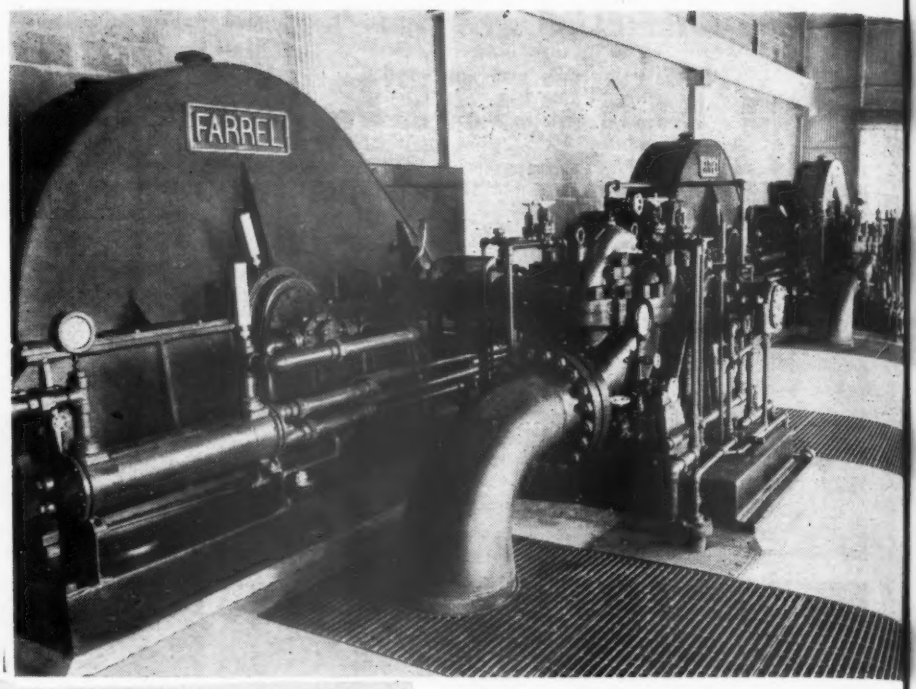
ALSO COLLAR LEAK CLAMPS, HIGH PRESSURE REPAIR SLEEVES

DRESSER®

COUPLINGS

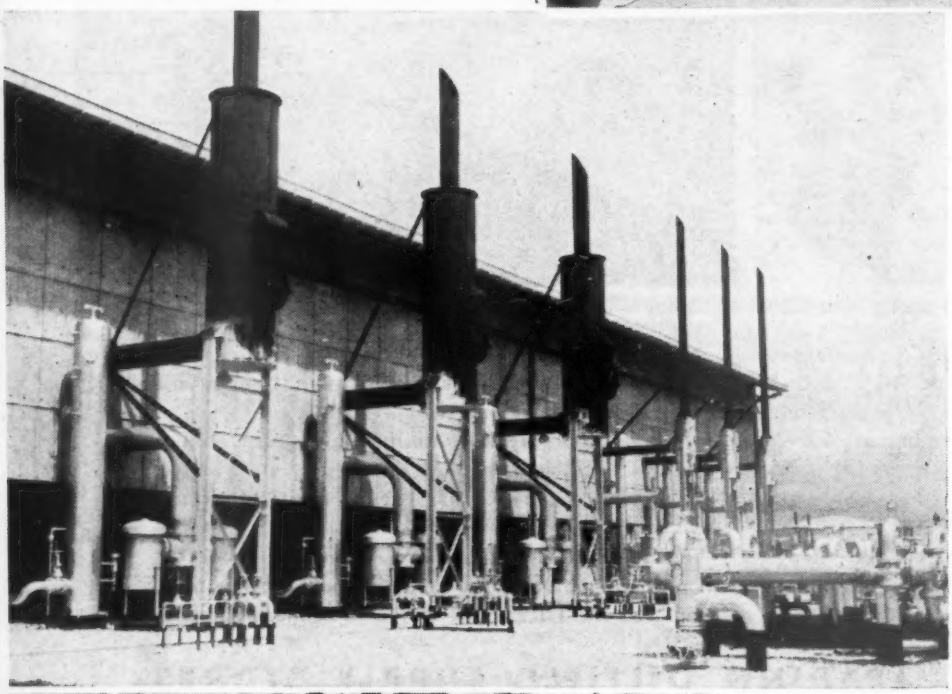
Dresser Manufacturing Division, 49 Fisher Ave., Bradford, Pa. (One of the Dresser Industries). Warehouses: 1121 Rothwell St., Houston, Texas; 101 S. Bayshore Highway, South San Francisco, California.

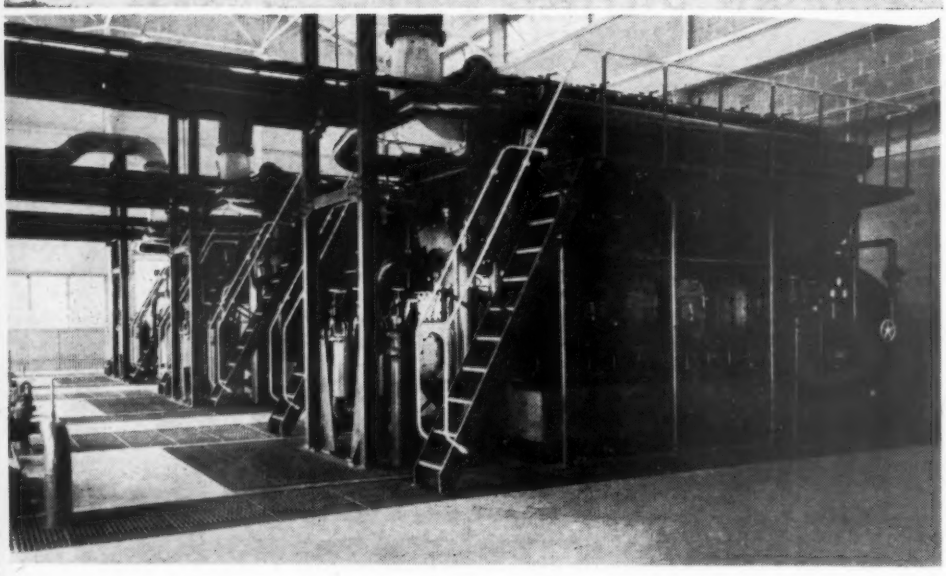
Right, centrifugal pumps are driven through speed increasers, with speed at ratio of 7.66 to 1.



Center, exterior view of pump station for Shell Caribbean Petroleum Company's "lightline." Capacity of the 165-mile, 30-in. line is 235,000 bbl of crude oil a day.

Bottom, three 12-cylinder gas diesel engines pump oil through pipe line. Engines are rated 1850 hp each, atmospheric, and are equipped for supercharging to boost output to 2500 hp each.





Automatically Controlled Gas-Diesels

THE 30-in. pipe line in Venezuela, a joint project of the Shell Caribbean Petroleum Company, Mene Grande Oil Company, and the Texas Petroleum Company, is outstanding for its wide flexibility of operations. The 165-mile line, often referred to as Venezuela's "lightline" was built and is operated by the Shell Caribbean Petroleum Company. It has a line capacity of 235,000 bbl of crude oil a day from the fields in the Mara and Maracaibo districts of the state of Zulia to Shell's refinery at Cardon and the terminals at Las Piedras, State of Falcon.

The single station at Palmarejo de Mara provides the necessary pumping capacity for the entire line. Here three 12-cylinder gas-diesel engines[1] drive centrifugal pumps[2] through speed increasers.[3] The centrifugal pumps are 12 × 12 × 24. The speed increasers have a ratio of 7.66 to 1.

Particularly noteworthy on this installation is the speed control achieved with the gas-diesel engines. This is done by using pneumatic controllers[4] in place of conventional governors. The pneumatic controllers actuate the variable

[1]Cooper-Bessemer Type LSV
[2]Byron-Jackson
[3]Farrel-Birmingham
[4]Taylor Tri-Act

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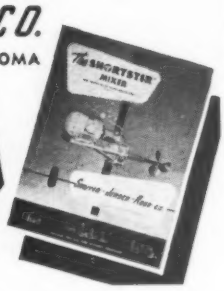

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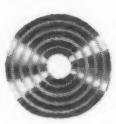

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timing of the engines as well as engine intake manifold pressure while the engines are operating as gas-diesels. When the engines are operated on straight oil diesel, the pneumatic controls govern the variable timing and fuel oil pressure.

The automatic engine speed control initiates from the discharge pressures of the pumps, which in turn govern the air pressure for actuating the pneumatic engine controls. Through such an arrangement line load is automatically balanced between the three pumping units, which operate in series. Engine idling speed is maintained by a low pressure stop in the piping system. Pipe line safety controls consist of a low pressure mercoid switch set at 750 psi and a high-flow limit of approximately 5 per cent over normal line capacity.

In addition to automatic operation, manual speed control is provided from the station's main switchboard and from individual control panels on each engine.

A 30-in. line of a 5/16 to 7/16-in. wall thickness, the 165-mile "lightline" starts at Palmarejo de Mara just north of Maracaibo and parallels the southern shore of the Gulf of Venezuela to Las Piedras on the Paraguana Peninsula. A 7-mile crossing at a point where the opposite shores of Lake Maracaibo are relatively close, has two 20-in. lines instead of the single 30-in. line. These 20-in. lines, each of ¾-in. wall thickness, are laid on the lake bottom in 9-ft trenches situated 1000 ft apart. The crossing at the Golfete de Coro is 30-in. pipe of ½-in. wall thickness laid on the bottom. Although the rating of the line is 750 psi, pipe joints have been tested to 900 psi except at crossings where test pressures went to 1000 psi.

To meet present demands, the engines operate as asmospheric units with ratings of 1850 hp each, providing a total of 5550 hp. Each engine, however, is equipped with turbocharger-type exhaust manifolds and shifting camshafts for eventual mounting of superchargers, thus boosting engine capacity to 2500 hp per unit for a total potential of 7500 hp.

Current operating schedules call for delivery of 90 per cent of throughput to the Shell installation at Punta Cardon. The remainder goes to the terminal of the Mene Grande Oil Company at Las Piedras for transhipment by that company on its own behalf and for account of Texas Petroleum Company.

* * *

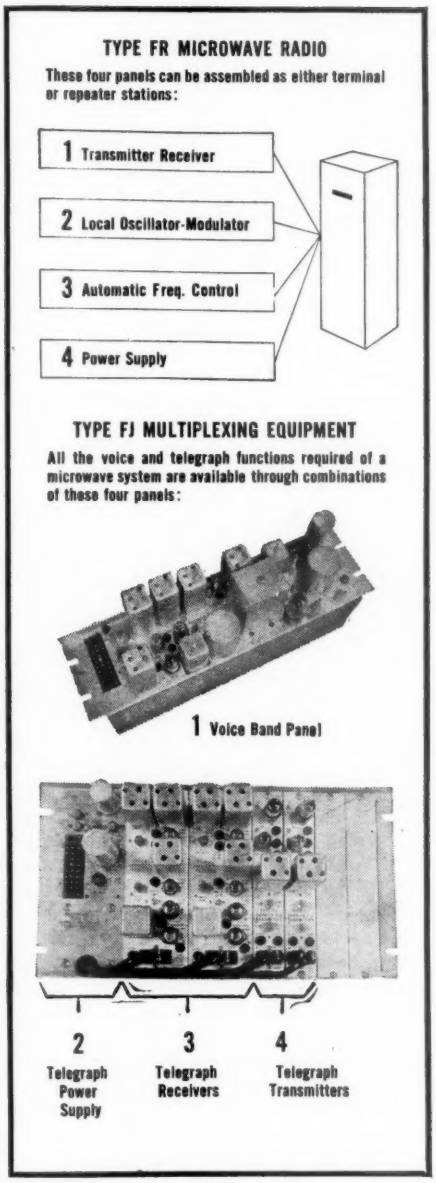
Oil Storage Capacity Rises

Oil industry must maintain approximately 100 bbl of petroleum storage capacity for every 50 bbl of oil held. Industry's capacity to store and handle crude oil and refined products has increased greatly in last 4 years. Total storage capacity for crude oil amounted to 429,400,000 bbl on March 31, 1952 and the storage capacity for crude oil and for petroleum products has expanded greatly since then.

Westinghouse Microwave Letter

WESTINGHOUSE ELECTRIC CORPORATION, ELECTRONICS DIVISION, 2519 WILKENS AVE., BALT. 3, MD.

Flexible System Design Uses Four Basic Panels For Radio, For Multiplex Functions


TYPE FR MICROWAVE RADIO
These four panels can be assembled as either terminal or repeater stations:
1 Transmitter Receiver
2 Local Oscillator-Modulator
3 Automatic Freq. Control
4 Power Supply
TYPE FJ MULTIPLEXING EQUIPMENT
All the voice and telegraph functions required of a microwave system are available through combinations of these four panels:
1 Voice Band Panel
2 Telegraph Power Supply
3 Telegraph Receivers
4 Telegraph Transmitters

Westinghouse 2000 MC Microwave—These eight flexible, interchangeable panels are compatible with any type of interconnected equipment.

The many practical uses of microwave communications and control systems can be enhanced by engineering skill. Flexibility of design, for instance, is one important measure of the quality of service you will get from any microwave system. Here's how Westinghouse 2000 MC Microwave is engineered for flexibility . . . to give you the reliable, long-term service you should expect.

Design Goal: Flexibility

First of all, Westinghouse studied user requirements . . . and reviewed its many years of practical experience in microwave communications and in the manufacture and application of all types of end-use equipment. Then Westinghouse designed the 2000 MC system, stripping away non-essentials to attain an effective minimum of flexible, interchangeable equipment.

The illustration shows you the result: two streamlined assemblies—Type FR Microwave Radio and Type FJ Multiplexing Equipment—each having only four basic panels. These eight panels are completely adequate for all radio and multiplex functions. System modification, parts stocking and maintenance are thus reduced to their simplest possible terms.

For 30 Voice Channels: One Panel

The four radio panels can be assembled for either terminal or repeater station operation. The four multiplexing panels are even more versatile. A single Type FJ Voice Band Panel—completely self-contained even to having its own power supply—is useable for any of the 30 voice channels supplied by Westinghouse microwave. All that is required is a change of crystal and retuning.

What's more, Type FJ Voice Band Panels are adaptable to party-line or private-line service; to two-wire or four-wire termination; to all types of signaling. Party-line service requires no additional equipment and is free of complicated circuitry. Built-in signaling allows immediate push-to-talk operation of remote VHF base stations.

For Telegraph Channels: Three Panels

Any of the 30 available channels can be used for telegraph functions by employing telegraph equipment instead of the Voice Band Panel. Each channel so used can be submultiplexed to handle up to 15 circuits for telemetering, supervisory control, teletype, relaying and others. All of these functions depend on only three basic multiplex panels: small, compact Type FJ Telegraph Transmitters and Receivers that mount individually on the Type FJ Power Supply Frame. All that is required to convert a telegraph unit from one frequency to another is a change of crystal and retuning.

For Each Channel: Independent Operation

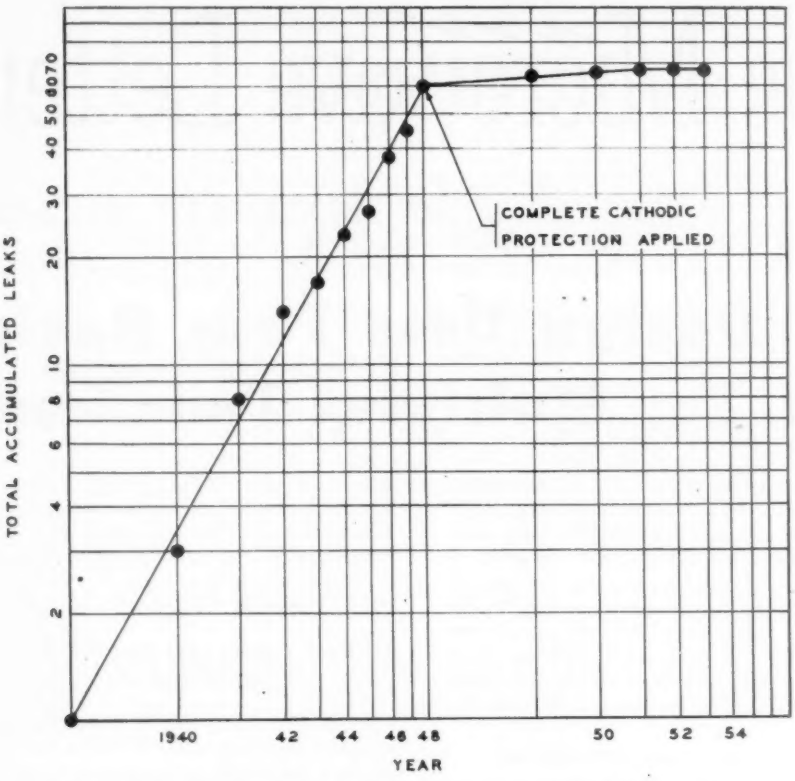
The great capacity of Westinghouse 2000 MC Microwave—up to 30 voice channels or 450 telegraph channels—can fulfill most present needs and accommodate future needs. Since Westinghouse microwave uses frequency-division multiplexing, these channels have maximum independence of each other. If one channel develops a fault, all other channels continue to operate without interruption.

Flexibility—and reliability, too. That's the essence of Westinghouse 2000 MC Microwave. Get full details now about this complete system of communications. Call your Westinghouse representative or write: Westinghouse Electric Corporation, Electronics Division, Microwave Section, 2519 Wilkens Avenue, Baltimore 3, Maryland.

Ask for our Microwave Booklet.

YOU CAN BE SURE...IF IT'S Westinghouse

J-02276



This leak frequency plot is a time-frequency history of leaks on a pipe line system. In typical example, plot illustrates difference in number of leaks on a line during a 10-year period before and a 5-year period after application of cathodic protection. Approximately 60 leaks appeared in 10 years prior to application, less than 10 leaks in 5 years after installation.

Pipe Line Leaks Are Not Inevitable

An estimated $500,000,000 annual pipe line loss from corrosion can be economically controlled

WAYNE A. JOHNSON

The Author

Wayne A. Johnson is the owner of Corrosion Rectifying Company of Houston, Texas, specializing in designing and installing cathodic protection systems for pipe lines and refineries. He was previously with The Texas Pipe Line Company and later with Cathodic Protection Service at Houston, as a senior corrosion engineer. A graduate of Texas A & I College, Kingsville, Texas, he is an overseas veteran of World War II, having served with both the Seabees and the U. S. Navy.

It has been estimated that corrosion of underground steel pipe lines costs the oil and gas pipe line industry more than $500,000,000 annually.[1] A substantial percentage of this sum is expended each year to repair underground pipe line leaks with clamps, patches, slabs, and half-soles when most of them could be prevented economically by the use of cathodic protection—a method of corrosion prevention known for more than 100 years.

This continued waste of time and resources seems to indicate, despite the increasingly numerous cases of proved application and reported technical advances in cathodic protection in the past few years, that many companies apparently have failed to investigate the why, when and how of its use.

Any investigation of the fundamentals of cathodic protection should start with the cause of pipe line leaks.

Causes of Leaks

Most pipe line leaks result from electric current leaving the pipe at specific points and entering the adjacent soil, continually removing metallic particles of the pipe during this process.

Eventually the reduced wall thickness at such points of current departure is unable to withstand the internal pressure of the fluid stream.

This flow of electric current from pipe lines is caused by an electrical pressure or potential being developed between specific points on the same line or between sections of adjacent pipe lines, all buried in the common soil environment.

Required electrical pressure to start the current flow may be developed in many ways:[2]

1. By having pipe lines composed of dissimilar metals connected to one another and buried in the soil. For example, if a galvanized steel conduit were connected below ground to a length of copper tubing, the copper tubing would tend to be protected at the expense of the conduit.

2. By having a buried steel pipe line pass through dissimilar soil or soils of different electrical conductivity. It will be found that some soils are much more conducive than others to corrosive action on the pipe.

3. By having a pipe line in such proximity to electric trolley tracks or nearby cathodically protected pipe lines, it acts as part of the circuit for these systems, picking up and discharging the resulting stray currents.

Protection

As the most common form of underground pipe line corrosion is caused by current leaving the pipe line and entering the surrounding soil, it appears logical that this corrosive action can be stopped by opposing such flow with an equal or greater flow of current. Cathodic protection accomplishes this result by increasing the electrical pressure in such a manner that the flow of electric current is in the opposite direction, that is, from the soil to the pipe.

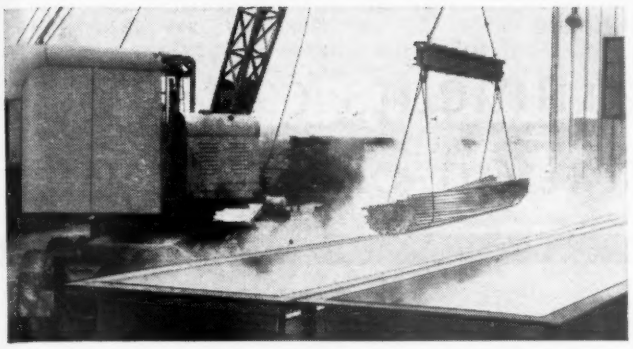
For many years it has been known that the application of an electrical pressure of approximately 0.85 volts, pipe negative to the soil, has a tendency to prevent corrosion pits and leaks from developing on pipe lines that are maintained by cathodic protection systems at such an electrical pressure. Laboratory investigations have lately confirmed the efficacy of this value.

By means of electrical test meters,

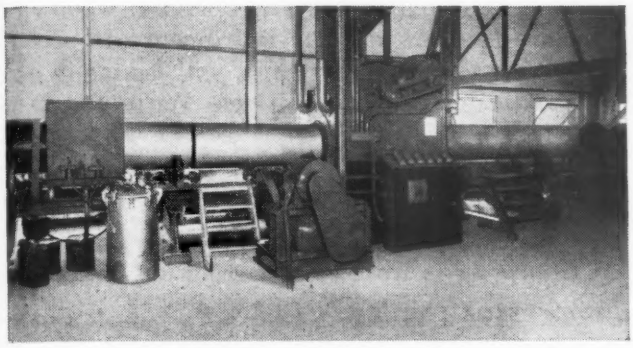
[1] H. H. Uhlig, *Chemical and Enginering News*, September 1949.

[2] *Corrosion, Causes and Prevention*, F. N. Speller, McGraw Hill, 1951 (Rev.).

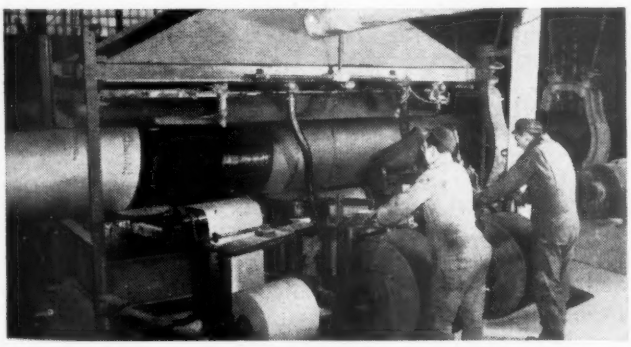
EXCLUSIVE



HOT CAUSTIC DIP removes all cutting oil and grease. Pipe is then rinsed in clear, hot water and dried in warming room. Throughout Hill, Hubbell process, pipe is kept at 80-90° to prevent moisture condensation.

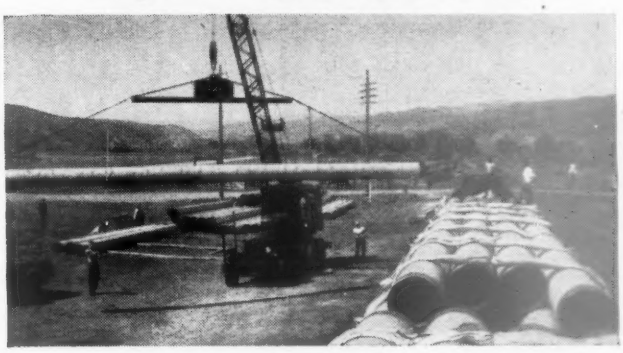


ROTO GRIT BLAST removes all mill scale and rust, cleans pipe to bare, bright metal, provides a slight "tooth" to hold coatings in positive bond. Priming coat is applied immediately after Roto Grit Blast.



SECRET of Hill, Hubbell superiority is applying enamel in multiple 1/32" coats instead of one thick coat—pipe protection insurance that pays off in the field. Then pipe is tightly wrapped under even tension by special machines.

Why HILL, HUBBELL Factory-Coated Pipe Lasts Longer



ELECTRONIC holiday detectors inspect every length of pipe before it leaves a Hill, Hubbell plant—further insurance that coatings have dielectric strength to resist electrochemical corrosion underground.

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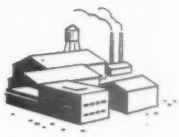

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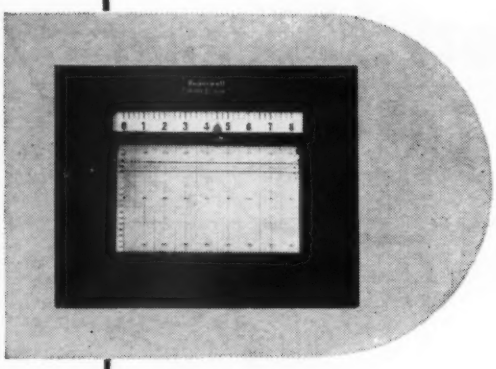
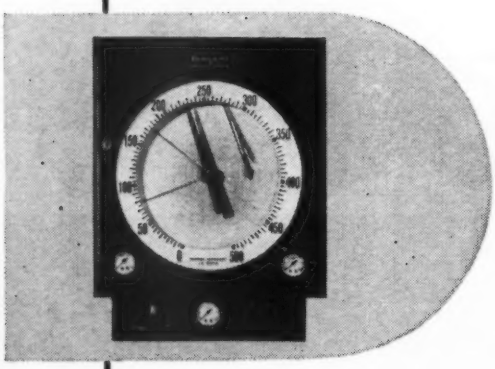


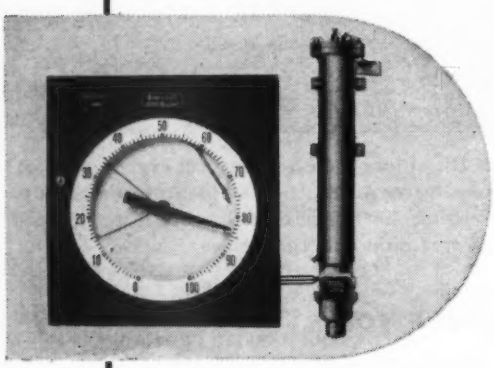
Monitoring critical temperatures:

The multi-point *ElectroniK* recorder logs temperatures at "hot spots"—in pump motor windings, bearings, pump glands and pump casings—automatically warns operators when vital equipment begins to overheat. The instrument can accommodate 16 separate temperature points, with as many as 8 independently adjustable alarm settings. Write for Data Sheet No. 7.2-4.



Controlling compressor cooling:

In natural gas compressor stations, control of amount of heat exchanged in engine water jackets proves a highly effective means of reducing engine wear. An *ElectroniK* instrument measures temperature difference between inlet and outlet water by means of accurately matched resistance thermometer bulbs . . . automatically controls water flow. Write for Data Sheet No. 7.2-3.



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Flow measurements can be transmitted from distant locations to a central control panel by means of the *ElectroniK* inductance bridge receiver. A choice of electric meter bodies covers the range from fuel oils to high pressure gases. Electric transmission makes measurements instantaneous and precise. Instruments have highly readable, evenly graduated scale . . . can accommodate up to 16 separate points . . . can be equipped for telemetering. Write for Bulletin No. 1540.

Your local Honeywell engineering representative will be glad to discuss how your pipeline can utilize these and other *ElectroniK* instruments. Call him today . . . he's as near as your phone. MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4475 Wayne Ave., Philadelphia 44, Pa.

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corrosion engineers determine "pressure values" existing between the soil and pipe at selected points along the lines. This enables them to determine when protection has been achieved, locate corroding or pitting points and, with slight modifications in technique, make many other evaluations.

Types of Systems

Several excellent means are available today to provide cathodic protection of pipe lines. Two most common are cathodic rectifier units and sacrificial anodes.

Cathodic rectifier units take a source of a-c power, step down the voltage, pass the resulting increased current through rectification plates to render it essentially direct, and introduce the current to the soil through "ground beds" usually consisting of several graphite anodes or rods buried in the ground and surrounded with a carbonaceous backfill.

A rectifier unit of practically any capacity or rating can be obtained today for solid-base or pole mounting with the component parts either oil immersed or air cooled.

Sacrificial anodes are bars of metal that, unlike the graphite anodes used with rectifier units, do not require an external source of current but supply their own because of the electrical pressure developed when connected to the buried steel pipe lines. This developed pressure forces current onto the pipe, thus opposing any corrosion currents within its particular field of influence. The most common types of sacrificial anodes employed today are made either of magnesium or zinc.

Some of the important advantages peculiar to each of the two major systems of applying cathodic protection are:

Advantages of rectifier units:

Can be designed for installation in soils of high resistivity.

Relatively convenient to vary the output of units.

Generally dependable operation with little required maintenance.

Advantages of sacrificial anodes:

Flexibility of use—can be placed at specific points on lines.

Require less current to protect a given length of pipe line because of distributed nature.

Require no easements because of installation close to line.

Require no external source of power.

In some high resistivity soil areas where no source of a-c power is available, wind-driven generators or gas generators may be used, depending upon the availability of gas and general economics.

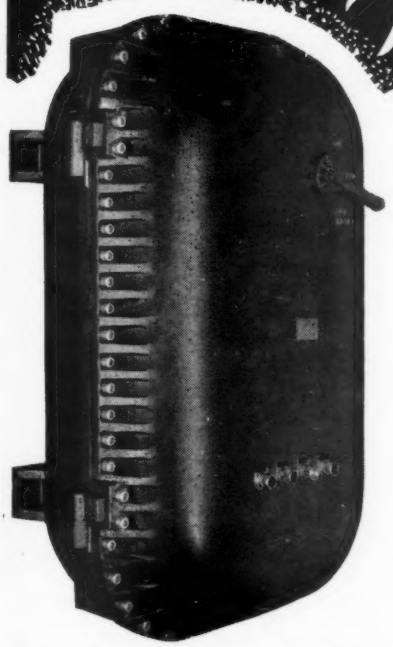
Economies of Protection

Economic studies indicate, as a general rule, that complete cathodic protection should be employed on all well-coated lines buried in soil that is known to be corrosive or in soil that is generally low in electrical resistivity. Low resistivity soils provide better paths for the electric corrosion currents to develop and maintain themselves.

Typical pipe line rectifier installation.

In most cases, bare pipe lines located in the same area would be too costly to completely protect cathodically. For such lines spot cathodic protection has proved to be both effective and economical. Spot cathodic protection consists of locating most of the actively corroding areas along a line and arresting the action at these spots by means of cath-

Now! A SIZE 5 EXPLOSION-PROOF STARTER with AIR CIRCUIT BREAKER



The "NEMCO" Size 5 Explosion-Proof Combination Motor Starter with Air Circuit Breaker — — for use in Class 1, Group D Hazardous Locations. "Start-stop" control station and reset buttons are mounted in cover.

The "NEMCO" Size 5 Explosion-Proof Combination Motor Starter is probably the only starter of its size and type to be manufactured in the combination air-break form.

Desirable features include: Rugged enclosure of gray iron; ground flange surfaces; heavy pin-type hinges; available with control stations or pilot lights in cover; can be furnished with sealing hoods for conduits. Interior has ample space for incoming and outgoing leads as well as for auxiliary relays, control transformers, etc.

The size 5 starter unit, air circuit breaker and all other components are the finest that money can buy.

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odic protection, usually with some form of sacrificial anode.

In order to evaluate properly the overall economy of applying cathodic protection to a pipe line, an economic balance should be made estimating the cost of cathodic protection against the estimated normal leak cost without cathodic protection. This balance should be based upon a convenient period of time —usually a year—and should include the following items:

Cost of cathodic protection:
Fixed charges on capital investment.
Operating costs.
Inspection and maintenance costs.
Cost without cathodic protection:
Leak repair costs.
Loss of revenue from leaks.

Other costs that should be considered under "Cost Without Cathodic Protection" include possible damage claims resulting from leaks, loss of metal in pipe resulting in decreased salvage value, and possible early reconditioning or replacement of the line.

Of help in predicting the number of future leaks on the line, provided it already has a leak history, is a leak frequency plot consisting of accumulated leaks plotted on the log ordinate versus time plotted on the log abscissa.[3] The accompanying chart illustrates such a plot and shows, in a typical case, what happened to the leak frequency after cathodic protection was installed on a particular pipe line at the end of the fifth year.

In order to procure the savings resulting from the early installation of cathodic protection, the economic balance should be made as early as possible and before increasing leak frequency and rising maintenance costs force either its adoption or expensive line reconditioning or replacement.

Most large pipe line companies today find it economical to apply excellent coatings to their new pipe lines and to follow closely thereafter with some complete system of cathodic protection. This procedure seems reasonable when it is realized that the annual cost of providing complete cathodic protection to 100 miles of coated 12-in. pipe line may often be as little as $400 per year including fixed charges, operation, inspection and maintenance costs.

Whether by means of cathodic rectifier units or sacrificial anodes, the increasing mileage of underground pipe lines placed under cathodic protection each year indicates many companies are discovering pipe line leaks caused by corrosion are not inevitable—that they can be economically prevented or arrested by means of cathodic protection.

[3]*Control of Pipe Line Corrosion* by O. C. Mudd.

★ ★ ★

Pipelines, the intricate system by which oil travels underground, totaled 168,301 miles as of January 1, 1953. Some 27,800 miles of these pipilines carry refined products to market places. First interstate crude oil pipe line was completed from Bradford, Pennsylvania to Bayonne, New Jersey, in 1888.

When it's time to buy SPEED INCREASERS Farrel has the exact unit you need

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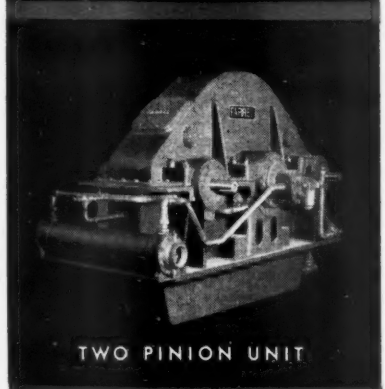
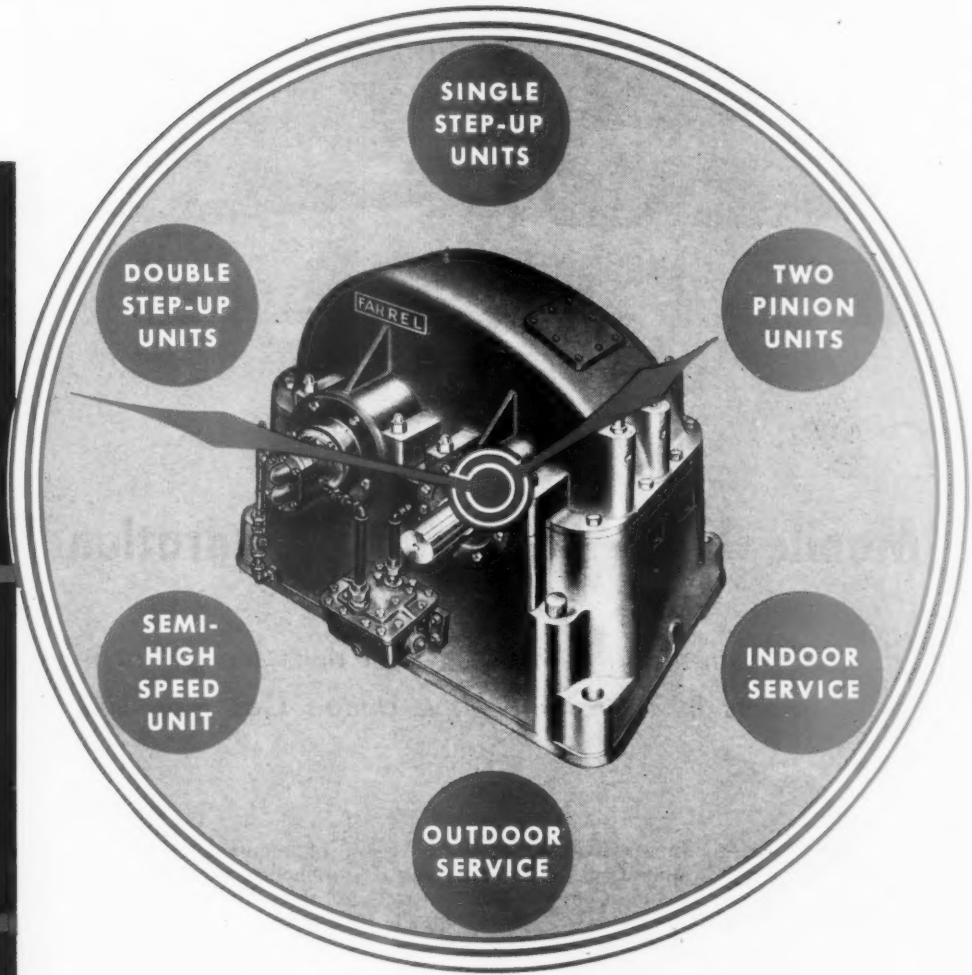
DOUBLE STEP-UP UNIT


TWO PINION UNIT

SEMI-HIGH SPEED UNIT



Farrel Type SI units are built in a standard line, consisting of 49 sizes.

Single step-up units have ratios ranging from 1:1 to 12:1. Where higher ratios are required, double step-up units are supplied with ratio range from 12:1 to 40:1.

Two-pinion units, designed to transmit power from a single engine to two pumps are also available.

When requirements fall between the range of Type SI units and standard commercial speed reducers, Farrel semi-high speed units are recommended.

Farrel engineers will be glad to help you select the right gear unit for your high-speed application. Write for further information about any of the types mentioned.

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FB-849

Compact and rugged, two custom-made trailer units such as the one shown here are now being used for dehydration plant repairs.

Mobile Units Used for Dehydration Plant Repairs*

Custom-made complete repair units service larger type dehydration plants in operation in the United Gas Pipe Line Company system

To SERVICE some of the new, larger type dehydration plants in operation in the system, United Gas Pipe Line Company is now using two custom-made, mobile repair units.

The traveling units are housed in heavy, four-wheel trailers and are equipped to do any dehydration repair work, including overhaul. They carry four-man crews consisting of a foreman and three specialists in various types of repair work and of maintenance work.

One unit is stationed in the New Orleans district, and the other handles all work for the Houston-San Antonio area.

Complete machine repair units on wheels, they have built-in air compressors to drive the impact wrenches, air hoists, air-driven winches, and certain other machine equipment. They also operate spray painting gear, etc. An automatic hopper device is included in each unit to load and unload desiccant (drying) beds, and screens are provided to screen the material when replacing a desiccant bed.

Other equipment includes all sorts of handtools, floodlights, collapsible aluminum ladders, etc.

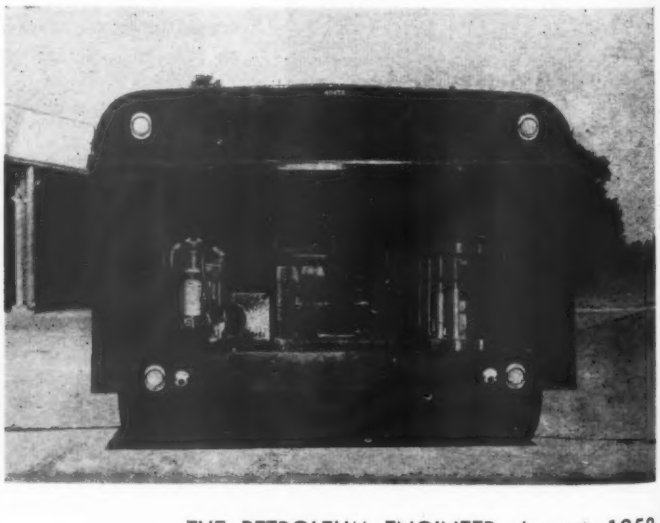
Safety features include electric brakes, emergency lights, turn indicators, and fire extinguishers.

The units, built in Shreveport, have now been in operation for several months. * * *

*Published by permission of *United Gas Log.*

Visible in these side compartments are screens to screen desiccant beds, center, and spray painting gear at right.

Air-driven winch installed in the rear section of the trailer. The units have their own built-in air compressors.



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$1,900,000,000 to Be Spent for Gas Lines

Gas industry plans $4,000,000,000 in new construction in 1953-56, nearly 50 per cent on transmission lines

THE nation's gas utility and pipe line industry will spend almost $4,000,000,000 for construction of new facilities and expansion of present plant during the four years from 1953 through 1956, the American Gas Association reports. This compares with construction expenditures of about $4,700,000,000 in the four years 1949-1952.

About $1,900,000,000 of these proposed expenditures, or slightly less than 50 per cent of the total, will be spent on transmission facilities and $1,400,000,000 or approximately one-third of the total, will go for distribution expenditures. The remaining $637,000,000 are to be spent for production, underground storage and general facilities.

Because of difficulty in anticipating future market conditions, information regarding the probable sources of necessary funds was supplied by fewer than half of the reporting companies.

These companies indicated they expect to obtain 29 per cent of needed funds from internal sources, primarily undistributed earnings and depreciation accruals. The remaining 71 per cent to be secured from outside sources is divided—51 per cent from long term debt and 20 per cent from common or preferred stock issues.

Expenditures High in 1952

The gas industry in 1952, for the third consecutive year spent more than $1,000,000,000 on construction of new facilities. Although falling short of the peak year of 1951, the 1952 construction budget of $1,067,400,000 was only about $105,500,000 less than had been originally estimated. Continued anticipated difficulties in obtaining steel pipe and delays in rate case settlements deferred applications for some new pipe line projects in 1952. Important declines in transmission expenditures were brought about by the greater dependence of the natural gas transmission industry upon new compressor installations, rather than pipe facilities, to augment capacity.

Anticipated construction expenditures during 1953 indicate that nearly $1,400,000,000 will be expended, making this year's the second greatest exenditure record for the gas utility and pipe line industry. In 1951 a total of $1,461,500,000 was spent. The new 1953 estimate is about one quarter billion dollars less than was estimated a year ago for this year. Continued delay in approving construction of pipe line facilities for the transmission of natural gas to the Pacific Northwest is a major reason for this drop. Some pipe line plans also have been temporarily shelved.

Extension of existing and new transmission lines will account for more than $809,000,000 in 1953. This increase over 1952 is attributed to new pipe lines from the Gulf Coast area to the Applachian region, the line from the Permian Basin to the midwest, and to major expansions in existing lines in the midwest, southwest, and southeastern areas.

Expenditures of $347,000,000 are contemplated for distribution facilities during 1953, to serve the ever-increasing number of new customers. In 1952 more than 900,000 new customers were added to gas utility lines. For the past four years the average gain has been 902,000 customers a year.

Much Construction Planned

Construction plans for underground storage facilities continue to stress the importance of such facilities in meeting peak load requirements. The industry expects to spend over $38,000,000 for new underground storage facilities in 1953, nearly double the $20,000,000 anticipated last year for the comparable period of time. During the next four years such expenditures are estimated at over $134,000,000, as compared with $42,000,000 estimated twelve months ago for the same period.

Construction expenditures for natural gas facilities continue to account for more than 90 per cent of total expenditures. For the four years from 1953 through 1956 the forecast for natural gas expenditures is over $3,600,000,000, compared with actual expenditures of $4,300,000,000 in the 1949-1952 period. For 1953 alone, it is estimated that natural gas construction expenditures will be over $1,290,000,000 or 91.6 per cent of estimated construction expenditures for the year.

Construction expenditures for the manufactured, mixed and liquefied petroleum gas utilities are relatively small. Estimates by this group reflect proposed conversions by several manufactured and mixed gas companies to natural gas distribution.

Data covering actual expenditures in 1952 and projected expenditures for 1953 were submitted by companies representing more than 90 per cent of total gas industry revenues. Forecasts beyond 1953 are the result of data recently reported to AGA by a substantial number of pipe line and large distribution companies. * * *

Gas utility and pipe line construction expenditures, by type of gas and by plant function, 1952-1956.

(Millions)

Type of gas and plant function	Actua 1952	Forecast 1953	1954	1955	1956	Total forecast 1953–1956	Total actual 1949–1952
Natural gas-total	$ 976	$1291	$ 967	$ 688	$ 662	$3608	$4283
Production	111	142	55	43	41	281	517
Transmission	493	802	528	295	293	1918	2641
Underground storage	43	38	54	27	15	134	†
Other storage	1	1	2	3	1	7	†
Distribution	286	269	304	295	289	1157	976
General	42	39	24	25	23	111	149
All other types of gas—total	91	118	90	82	79	369	403
Production and storage	20	28	20	18	21	87	113
Transmission	3	8	4	4	3	19	18
Distribution	63	78	60	56	52	246	250
General	5	4	6	4	3	17	22
Total industry-total	1067	1409	1057	770	741	3977	4686
Production and other storage	132	171	77	64	63	375	630
Transmission	496	810	532	299	296	1937	2659
Underground storage	43	38	54	27	15	134	†
Distribution	349	347	364	351	341	1403	1226
General	47	43	30	29	26	128	171

† Included in production.

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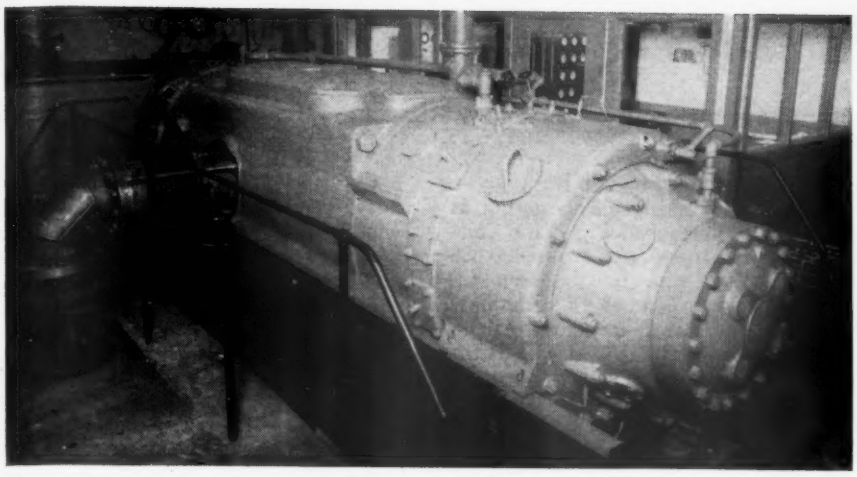


New prime mover development by Cooper-Bessemer is free piston engine driving a gas turbine.

Turbine Driven by Free Piston Engine

Compact but efficient new engine may solve problem of heavy-duty gas turbine prime mover

UNDER wraps for several years, Cooper-Bessemer's development work on the free piston engine driving a gas turbine is rapidly approaching what designers believe to be a practical solution to a heavy-duty gas turbine-type prime mover, yet one offering the high efficiency found in diesels.

High operating efficiency, which means low fuel consumption, is one of the free piston engine turbine's features. According to the development engineers, efficiencies as high as 40 per cent are possible with this unit.

On pipe line service the free piston engine turbine will require only seven cubic feet of gas an hour for each horsepower, including auxiliaries.

The gas turbine is nothing new in the power field. Gas turbines have been in use on jet aircraft for many years. Commercially, more than 49,000 hp is already installed or scheduled in this country's electric generating plants.

The basic difference between existing gas turbines and the free piston engine turbine is in the method used to supply the turbine with heat energy for conversion through rotary power.

In the conventional gas turbine, air for combustion is compressed by a rotary type blower. This blower or compressor is driven from the shaft of the gas turbine. After the air is compressed, the fuel is burned in a low pressure combustion chamber between the compressor and the turbine. This heat increases the temperature of the air, expanding it to propel the turbine. As power to drive the compressor is taken out of the turbine itself, the output of the turbine is reduced accordingly, and the more horsepower needed to drive the compressor the less power remains for useful work.

With the Coooper-Bessemer development, the free piston engine replaces both the rotary compressor and the low pressure combustors supplying hot gas under pressure to the gas turbine. The free piston engine provides its own high pressure combusion chamber within the engine's power cylinder.

The principle of the free piston engine driving the gas turbine has been known to power engineers for a long time. Practical usage began in small compressor units developed in Europe during World War II in submarines for supplying high pressure air to discharge torpedoes. Cooper-Bessemer undertook as part of its overall developmental program a project to investigate the free piston engine.

The gas turbine has always been attractive to power users because of its promise as a compact simple unit. Free of vibration, the free piston engine can be used on foundations smaller than the size needed for conventional prime movers. Its basic requirement is as much as 30 to 60 per cent less.

The free piston engine is basically a simple opposed piston internal-combustion engine without a crankshaft or connecting rods. The work of many pistons in the usual internal-combustion engine is handled by just two pistons, which oppose each other in a single cylinder.

Fuel is ignited in the space between the two power pistons. The burning gases force them apart to actuate compressor pistons directly attached to them. As the piston assemblies reciprocate, air pumped by the compressor pistons is directed through the combustion cylinder. This air cleans out or scavenges the hot gases of combustion in the cylinder and drives them through a pipe to propel the blades of the turbine rotor.

Cycling of the air through the free piston engine's cylinder keeps it cool and lowers the temperature of the gases going to the turbine. The combustion taking place at high temperature and pressure in the water-cooled cylinder permits the free piston turbine to operate with a high overall efficiency on exhaust gas discharged at 1000 F, after it has been expanded partially to compress its own air. This is in contrast to the high temperatures required in most conventional gas turbines at around 1350 to 1500 F at the present time.

One advantage of operating as low as 1000 F, explain Cooper-Bessemer engineers Ralph Boyer and Robert Ramsey, is that the turbine can be manufactured with materials normally available for civilian use. Further, the "creep" characteristics of high temperature materials stressed under high speeds and at high temperatures is a problem that has confronted metallurgists for many years.

Combustion in the free piston engines takes place at extremely high pressures and temperatures and the full expansion work is taken out of the cycle. Combustion in a conventional turbine takes place at much lower pressures, but at very high temperatures, it is pointed out. The free piston has its own compressor and combustor and the conventional turbine must drive its own rotary compressor.

In a simple cycle gas turbine producing, for instance, 5000 net horsepower at the output shaft, nearly 15,000 hp must be developed by the turbine's rotor with approximately 10,000 hp used to drive its own compressor.

Many devices have been developed to increase efficiency of the conventional rotary compressor type of gas turbine. Some machines recover waste heat from the turbine exhaust to help heat the air going into combustors. The heat from the exhaust supplements fuel burned in the firing chamber through a regenerator. The free piston engine does not require a regenerator because it uses the exhaust energy in the turbine itself. When compound turbines are used to gain pressure and efficiency, it is necessary to use intercoolers between compressors. The free piston requires no intercooling.

Another procedure in some continuous combustion turbines is to reheat the gases after passing through one turbine and before they go through another. This requires an additional combustion chamber. The free piston requires no reheat procedure. It is possible to burn extra fuel in the exhaust line before the gases from the free piston engine reach the turbine in order to gain high overload capacity. These devices increase the efficiency of the continuous combustion turbine. * * *

XUM

With the PIPE LINE CONTRACTORS

Anderson Brothers Corporation, P. O. Box 2591, Houston, Texas, has two spreads in operation on 180 miles of 30-in. line being laid between the Michigan-Wisconsin state line to Cooks, Michigan, for Lakehead Pipe Line Company. K. B. Killingsworth is in charge of the 90-mile section from the state line starting point to Crystal Falls, Michigan. Another 90-mile section from Crystal Falls to Cooks is being supervised by Aldress Kilgore.

Construction of 82 miles of 14-in. between Charlotte and Greensboro, North Carolina for Plantation Pipe Line Company is underway.

Between Scottsville, Kentucky, and Springfield, Tennessee, work is progressing on 48 miles of 30-in. pipe line for Tennessee Gas Transmission Company. Earl Saulsman is superintendent and Eddie Ball office manager.

Work has begun on 117 miles of 16-in. line from east side of Kalamazoo River, Michigan, to Wayne County, Michigan, Dick Leonard is superintendent and W. W. Kirk office manager.

Company has contract for approximately 70 miles of 3-, 4-, 12-, and 24-in. natural gas line for Gulf Interstate Gas Company in Louisiana.

Anderson International Constructors, Inc., Rawleigh Building, Edmonton, Alberta, Canada, is completing approximately 50 miles of 24-in. for Trans Mountain Pipe Line Company. The section is from the Pembina River to a point near Acheson, Alberta. The field office is at Stoney Plain, Alberta, with Frank Whitlow superintendent.

Work has also begun on 135 miles of 24-in. for Interprovincial Pipe Line Company, which will be laid in four loops in Saskatchewan and Manitoba. One spread is in operation in Manitoba with Dick Jernigan in charge.

Banister Construction, Ltd., 609 Northern Hardware Building, Edmonton, Alberta, Canada, will complete in August 110 miles of 10-in. pipe line for the Saskatchewan Power Corporation, between Saskatoon and Brock. The field office is at Rosetown, Saskatchewan. Buck Randel is in charge.

For Imperial Pipe Line Company, 15 miles of 8-in. from Nisku to Edmonton will also be completed in August.

Associated Pipe Line Constructors, Inc., Houston, Texas, is working on 200 miles of 10-in. line from Bismark to Fargo, North Dakota, for Standard Oil Company. Jim Ed Andrews is superintendent and Buck Johnson office manager at the Bismark field office.

Company is also working on 40 miles of 14-in. pipe line for Texas Company in Louisiana, from Paradise to Golden Meadow. Willie Briley is superintendent and R. N. Cain office manager.

Bechtel Corporation, 220 Bush Street, San Francisco, California, is acting as agent for the Lakehead Pipe Line Company, in constructing the $76,000,000 635-mile, 30-in. pipe line between Superior, Wisconsin, and the international boundary south of Port Huron, Michigan, and Sarnia, Ontario. It will act as agent in the management and construction of the project. An office has been established at 124 South Washington Avenue, Saginaw, Michigan. Van W. Rosendahl, senior vice president of Bechtel, is in charge. Assisting him are Clark Rankin, project engineer; J. V. Chambers, project administrative manager; J. Don Creveling, lands manager; E. F. Quiett, construction manager, and T. Ray Johnson, public relations officer.

Bechtel construction crews also are laying 75 miles of the line, the section from Mackinaw City to Red Oak, Michigan. The field office is at Gaylord, Michigan, with M. A. Roberts superintendent.

Another project by this company is 63 miles of 24-in. for the Tennessee Gas Transmission Company, from Kane to Coudersport, Pennsylvania. The field office is at Kane. J. L. Work is superintendent and K. F. Kenna office manager.

Brown and Root, Inc., 4100 Clinton Drive, Houston, Texas, is working on 194 miles of 6, 8, 12, and 20-in. pipe line for Southern Natural Gas Company in the coastal area of Louisiana. The spread doing the construction work from Lake Sand east to the Mississippi River has its field headquarters at Franklin, where E. R. Jackson is superintendent. From the Mississippi River east for a distance of aproximately 144 miles the spread is in charge of Jim Kincy, with field headquarters at New Orleans.

O. R. Burden Construction Corporation, P. O. Box 5216, Tulsa, Oklahoma, is constructing 153 miles of 12-in. and 16-in. crude oil line for Service Pipe Line Company between Tioga and Mandan, North Dakota. Two river crossings also will be installed. The field office is at Tioga. A. B. Haynes is superintendent and J. R. Perkins office manager.

L. E. Farley, Inc., 2609 Sunset Boulevard, Houston, Texas, is laying 64 miles of 16-in. pipe for Interstate Natural Gas Company, from Bateman Lake near Morgan City, Louisiana, to Baton Rouge. W. L. Barton is general superintendent over the two spreads, one of which has its field headquarters at Plaquemine and the other at Morgan City. Fred Hudson is office manager at Plaquemine. At Morgan City Jesse Finley is spreadman and Paul Upton office manager.

Work also is underway on 55 miles of 16-in. for Interstate Oil Pipe Line Company between Raceland and Plaquemine to a point near Baton Rouge.

Comstock Midwestern, Ltd., 206 Laird Drive N., Leaside, Ontario, Canada, is completing work on the Trans Mountain Oil Pipe Line Company system. The section is between Edmonton and Vancouver. Office is at Vancouver, British Columbia, with C. I. Rathgeb, Jr., project engineer, and K. A. Owens assistant.

There are four spreads. A. T. Maxwell is superintendent of the spread working out of Hope, British Columbia, and J. E. Jester is office manager. Another spread has it headquarters at Coquihalla, British Columbia, where Cliff Simmons is superintendent. A third spread has its field office at Blue River, British Columbia, with Doyle Crittenden superintendent and Walt Hammond office manager. The fourth spread is at Edson, Alberta. Denver Franklin is superintendent.

Conyes Construction Corporation, 2884 San Pablo Avenue, San Pablo, California, is working on 180 miles of 30-in. line for Lakehead Pipe Line Company from Red Oak to Marysville, Michigan. Two spreads are in operation, with J. L. Walker, Morris A. Norwood, and Chet Kinkaid, superintendents of the projects.

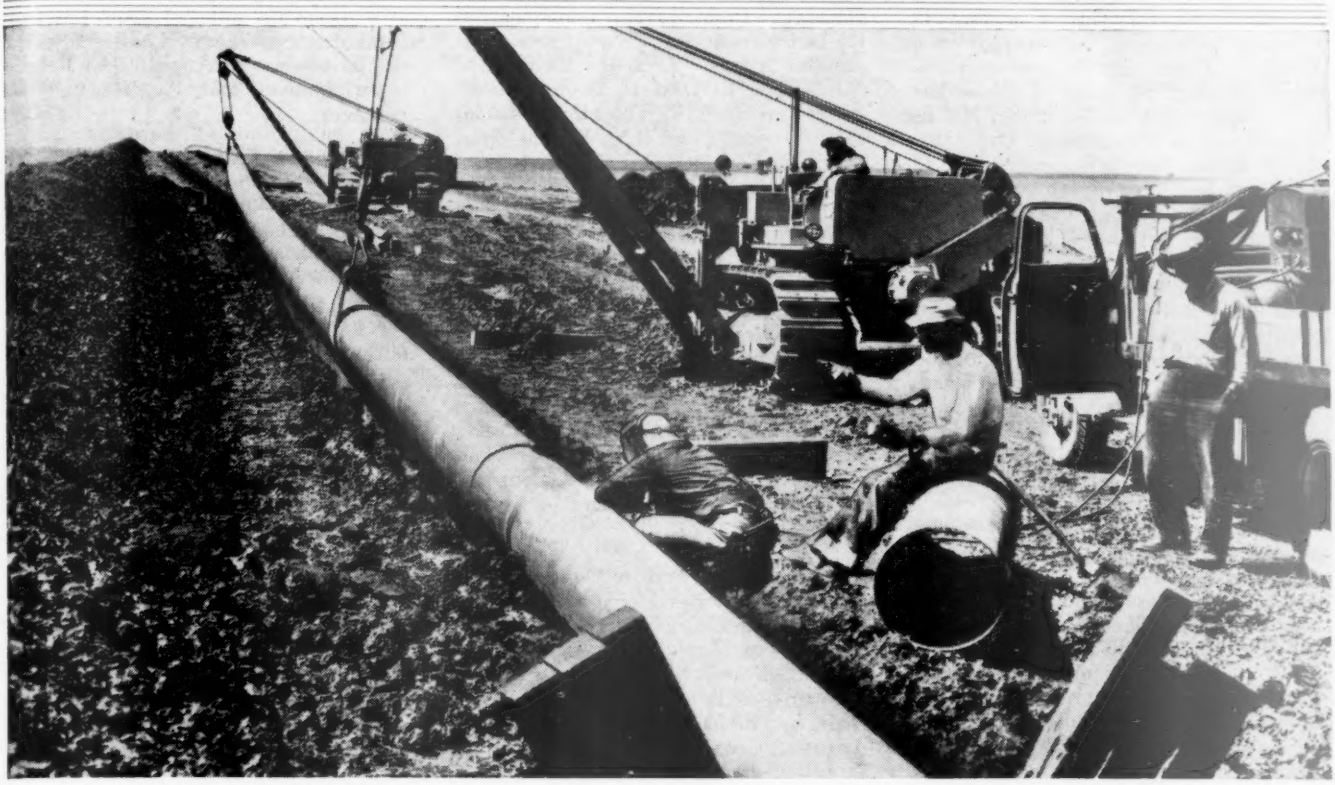
Engineering-Construction Company, 402 North Cheyenne, Tulsa 6, Oklahoma, is constructing 18½ miles of 6-in. line and 1 mile of 4-in. line for East Tennessee Natural Gas Company. Curt Vaughan is general superintendent and V. L. Bethel, office manager.

Company is also laying 11½ miles of 10-in. line for Gulf Refining Company near Pryor, Oklahoma, and taking up 7½ miles of 10-in. line in the same area. Bob Carriker is spreadman and H. B. Hoge, office manager.

Fulghum Contracting Corporation, Box 1181, Harrisburg, Pennsylvania, expects to complete by September 1 about 51.5 miles of 14-in. pipe line from Dupont, Pennsylvania, to the Pennsylvania-New York state line for Buckeye Pipe Line Company. R. L. McMillon is superintendent at the Montrose, Pennsylvania, field office. Dick Jablonowski is office manager.

Mahoney Contracting Company, 2300 North Grand River, Lansing, Michigan, is progressing on 91 miles of 30-in. pipe for Lakehead Pipe Line Company between Superior, and Hurley, Wisconsin. Field office is in Ashland, Wisconsin. Henry Mogg is general superintendent; Mike Finnerty, superintendent; Al McConnell, office manager; H. F. Emerson charge of front end; Ray Abney, charge of back end; Frank Barnard, material manager; John Kohler, ditch; Bill Morry, bending; Glen Goodson, pipe; George Hastings, welders; H. L. Sparks, dope, and Joe Gilbert, cleanup.

PIPE LINE PROGRESS



A string of A. O. Smith line pipe on location during construction of the Interprovincial-Lakehead pipe line.

24-inch looping project to increase Interprovincial pipe line crude capacity

About 135 miles of 24-inch A. O. Smith line pipe is currently being lowered in to loop Saskatchewan and Manitoba section of 16-inch pipe in the Interprovincial Pipe Line. This will add capacity to a transmission system which, by December, will carry western Canadian crudes from the Edmonton, Alberta, area to Sarnia, Ontario.

Upon completion, this will be the world's longest crude oil pipe line, totaling 1738 miles from Redwater to Sarnia.

All the 20-inch and 18-inch pipe in the original line, presently terminating at Superior, Wisconsin, is A. O. Smith pipe. The 20-inch main runs from Edmonton to Regina; the 18-inch completes the run from Gretna, Manitoba . . . just north of the U. S. boundary . . . to Superior.

The present 24-inch installations are part of extensive looping of the 16-inch sector joining the 20 and 18-inch section.

Shipments were made from both Milwaukee and Houston mills, in supplying Interprovincial. A. O. Smith takes pride in its ability to meet delivery schedules, anywhere on this continent, with its high quality, internally expanded, welded line pipe.

A. O. Smith Line Pipe is available in a complete range of sizes and wall thicknesses, from 8⅝-in. to 36-in. diameters.

FIRSTS by A. O. Smith: Welded line pipe • Internally expanded pipe • Light-wall large-diameter pipe • World's largest producer of large-diameter welded steel pipe.

The A. O. Smith Casing Mill is operating at capacity to supply vitally needed casing for the Oil and Gas Industry.

A. O. Smith

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Los Angeles 22 • Midland 5, Texas • New Orleans 12
New York 17 • Pittsburgh 19 • San Francisco 4
Seattle 1 • Tulsa 3 • Washington 6, D.C.

International Division: Milwaukee 1

DEPENDABILITY THROUGH RESEARCH AND ENGINEERING

Contractors

Houston Contracting Company, Ltd., 2707 Ferndale Place, Houston, Texas, has the following construction work:

Approximately 440 miles of 14, 16, 18, 20, and 24-in. natural gas lines for Southern Natural Gas Company in Georgia, Alabama, Mississippi, and Louisiana. Two spreads are at work. Approximately 68 miles of 24-in. has been completed from Gwinville, Mississippi, south to Franklinton, Louisiana. W. H. Hayes is superintendent, M. L. Thompson assistant superintendent, and J. B. Stoddard, field office manager. Headquarters are at Tylertown, Mississippi.

Approximately 73 miles of 20-in has been completed from Franklinton west to Mississippi River near Carville, Louisiana. F. A. Silar is superintendent, and L. F. Redfearn office manager. Headquarters are at Hammond, Louisiana.

Approximately 43 miles of 20-in. from Franklinton south to Lake Ponchartrain, to be handled by one or both of the above spreads.

Approximately 202 miles of 14-in., 16-in., and 18-in. in Georgia and Alabama. This work is to be done by one Houston contracting spread and one Latex of Georgia spread. The Houston Contracting spread is at Milledgeville, Georgia; H. L. Leake, superintendent; S. B. Harrison, assistant superintendent; Geo. Warner, field office manager. Pipe laying began June 15.

Approximately 20 miles of 18-in. reconditioning for Texas Gas Transmission Corporation near Greenville, Mississippi. Personnel and headquarters to be announced later.

Approximately 500 miles of 30-in. natural gas line for Gulf Interstate Gas Company from Rayne, Louisiana, to Kinkade, Tennessee. First spread in operation August 1, near Mayersville, Mississippi. E. C. Norris is superintendent of spread; R. E. Thornton, assistant superintendent, and R. J. Axsom, office manager. Two other spreads are to start in late August.

Ray L. Smith and Son, Inc., Hazlett Building, P. O. Box 391, El Dorado, Kansas, is constructing 234 miles of 8- and 10-in. products line between Wichita, Kansas, and Fairmont, Nebraska, for Kaneb Pipeline Company. Three spreads are in operation. R. M. Jones is superintendent and Tom Davis office manager for spread one; Carl S. Colvin is superintendent of spread two, and Dewey Whitworth is superintendent and D. L. Marley office manager on spread three.

Latex Construction Company of Georgia, P. O. Box 56, North Side Station, Atlanta, Georgia, is working on the 294 miles of 14, 16, and 18-in. pipe line contracted from Southern Natural Gas Company to be laid in Alabama and Georgia. Field headquarters are in Augusta, Georgia, with J. M. Phipps superintendent, Jim Davenport, spreadman, and A. C. Andrews office manager.

River Construction Corporation, 6100 Bowie Boulevard, Fort Worth, Texas, is taking up 1600 miles of 8- and 12-in. line for Sinclair Pipe Line Company in Kansas, Missouri, Illinois, and Indiana.

Work on 107 miles of 22-in. line from Bunkie to Shreveport, Louisiana, is expected to start in August. Jim Reed is superintendent and Pat Rogan office manager.

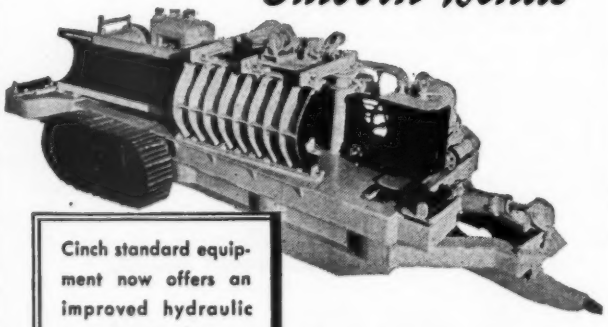
Oklahoma Pipe Line Constructors, 6612 Hines Boulevard, Dallas, Texas, is laying approximately 150 miles of 30-in. line for El Paso Natural Gas Company from Denver City, Texas, to near Roswell, New Mexico. A field office has been opened at Lovington, with Louis Visentine as superintendent and R. F. Mueller office manager.

Somerville Construction Company, Ada, Michigan, plans to complete about September 1, 102 miles of 12-in. products line for Standard Oil (Indiana), from Whiting, Indiana, to Colon, Michigan. The field office is at La Porte, Indiana. O. P. Hiner is superintendent and Tom Sargent office manager.

Lone Star Constructors, 10301 Shady Trail, Dallas, Texas, is constructing four loops, totaling 70 miles of 30-in. for Northern Natural Gas Company. One of the loops is in Nebraska and three in Kansas. A field office has been opened at Plattsmouth, Nebraska. H. A. "Red" Wylie is superintendent in charge and J. K. Little is office manager.

CINCH

Affords Faster, Smooth Bends



Cinch standard equipment now offers an improved hydraulic system and new wedge-type pin-up slide for greater durability and speed. If desired, even faster, easier maneuvering can be obtained with Athey tracks and hydraulic lift tongue.

Contractors swear by Cinch "Smooth Bend" Pipe Benders for dependability and uninterrupted service. Cinch Pipeline Equipment provides the most up-to-date equipment and expert maintenance.

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★ Anode Resistance
★ Circuit Resistance
★ Polarization Effects
★ Current Density

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MODEL 263

DEPENDABLE ground resistance measurement, with a one-man push-button-operated instrument! No cranking, leveling or "babying" in the field with Vibroground Model 263—And look at all these added advantages:

LIGHT—less than 10 pounds "on-the-job" weight.

PORTABLE — Not only light, but *small*—only 9" x 6" x 6½"!

POWER — Self-contained standard No. 2 flashlight batteries—good for months of continuous use before replacing.

RANGES—0-1, 0-10, 0-100, 0-1,000 ohms all set . . . fast . . . on single selector.

ACCURATE to less than 3% on any range.

RUGGED for years of trouble-free field service.

Write for Bulletin 105B

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Parkhill Truck Company, P. O. Box 1856, Tulsa, Oklahoma, reports the following work:

Ninety-one miles, Section I, unloading, stockpiling, and stringing of the 630-mile, 30-in. pipe line from Superior, Wisconsin, to the International Boundary, for Mahoney Contracting Company, contractor for Mackinac Pipe Line Company, Inc.

Ninety-seven miles, unloading, storing, and stringing on the same system for Midwestern Constructors. Also hauling and storing of about 9 miles of 20-in. river pipe from St. Ignace, Michigan, to the Mackinac Straits for Midwestern Constructors, Inc.

Stringing 280 miles of 14-in. and 320 miles of 8-in. takeup for Shell Oil Company from Wood River, Illinois, to East Chicago, Indiana. The prime contractor is R. B. Potashnick Company.

Stringing 180 miles of 8-in. pipe for the Indiana Farm Bureau between Mount Vernon, Illinois, and Indianapolis, Indiana. The prime contractor is R. B. Potashnick.

Stringing 16-in. line pipe on the Wolverine line from East Chicago, Indiana, to a point near Marshall, Michigan, for Midwestern Constructors, Inc.

Stringing from El Dorado, Kansas, to Arkansas City, Kansas, 74 miles of 8⅝-in. pipe, and 130 miles of 10¾-in. pipe from Potwin to McPherson, Kansas, and Fairmount, Nebraska, for Ray L. Smith and Son, Inc.

R. H. Fulton and Company, P. O. Box 1526, Lubbock, Texas, is constructing 63 miles of 18-in. line for El Paso Natural Gas Company between Clear Creek and Provo, Utah. Superintendent in charge is Jerry Nash with Jack Frazer the office manager.

Fulton is working on 260 miles of 16, 20, 24, 26, and 30-in. line for the Permian Basin Pipe Line Company in loops from Hobbs, New Mexico, to Denver City, Texas, to Midland, Texas, to Rankin, Texas, and back to Hobbs. Two spreads are working on the job. M. L. Boyd is superintendent at the Midland, Texas, field office, and Oscar Phillips is superintendent at the Hobbs, New Mexico, field office.

Construction is progressing on 91 miles of 12 and 14-in. pipe line for Platte Pipe Line Company between Winchester and Byron, Wyoming. A. A. Carrigan is superintendent and Dave Wagner office manager at the Worland field office.

Williams Brothers Company, National Bank of Tulsa Building, Tulsa, Oklahoma, is working on a gathering system in the Williston, North Dakota, area for Signal Oil and Gas Company, which will connect with the latter's gasoline plant. Approximately 150 miles of pipe, 4 in. through 30-in. will be laid. Eddie Hubach is in charge of work at the Tioga, North Dakota, field office.

Between Sarnia and Toronto, Ontario, Canada, work is underway on approximately 200 miles of 8-in. line for Sun Oil Company. Jimmy Childress is superintendent. Field office is at Strathroy, Ontario, Canada.

Two spreads are working on approximately 142 miles of gas line for Texas Eastern Transmission Corporation. Between Corrigan and Center, Texas, 714 miles of 24-in. line are under construction, with O. R. Mitchell, superintendent in charge and Walt Smetz, office manager. Field office is at Nacogdoches, Texas. About 70 miles is being laid between Center, Texas, and Castor, Louisiana, with T. E. "Thelma" Davis, in charge and Paul Mackie, office manager. Field office is at Coushatta, Louisiana.

Mannix, Ltd., Calgary, Alberta, Canada, has completed 226 miles of 24-in. for Trans Mountain Oil Pipe Line Company, from Blue River, British Columbia, to Coquihalla Pass. The operating office is at 412 Victoria Street, Kamloops, British Columbia. C. P. Baker is project manager, B. Montgomery, engineer, and A. F. Collins office manager.

G. G. Griffis Construction Company, 4450 East Admiral Place, Tulsa, Oklahoma, is working on three loops in Iowa for Northern Natural Gas Company. G. G. Griffis is general superintendent, Hook Miller spreadman, and R. H. Holmes, office manager at the Cherokee, Iowa, field office. The three loops are a 27-mile, 24-in. line, a 40-mile, 30-in. line and 32-mile, 30-in. loop.

Mary Construction Company, Cape Girardeau, Missouri, is working on 80 miles of 8-in. products line for the Indiana Farm Bureau Cooperative Association. The pipe is being laid between Switz City to Peru, Indiana. Garland Mims is superintendent and Lewis Wiist office manager.

H. C. Price Co., Pipeline Division, P. O. Box 1111, Bartlesville, Oklahoma, has the general contract covering construction of approximately 355 miles of 30-in. high pressure natural gas pipe line for Gulf Interstate Gas Company starting at a point near Kinkade, Tennessee, and extending northeasterly to a point near Kenova, West Virginia.

A general contract covers construction of 200.4 miles of 24-in. loop and new lines for Southern Natural Gas in Mississippi, Alabama, and Georgia.

Spreads in operation include spread one, Oil City, Pennsylvania, G. A. Reutzel, superintendent; spread two, Owensboro, Kentucky, R. L. Ezell, superintendent; spread three, Bessemer, Alabama, C. E. Shivel, superintendent; spread four, Columbus, Mississippi, C. R. Ice, superintendent, and spread five, Columbia, Kentucky, W. H. Olrich, superintendent.

Panama-Williams Company, 1417 Melrose Building, Houston, Texas, is progressing on the 194-mile, 16-in. products pipe line between Port Arthur, Texas, and Baton Rouge, Louisiana, known as the Evangeline Products System. Owners of the line are The Texas Pipe Line Company, Gulf Refining Company, and Sinclair Pipe Line Company. Texas Pipe Line is supervising construction. Two spreads are in the field. "Cooney" Shiflett is spreadman and Lloyd Evans, office manager, at Welsh, Louisiana, and Gene Coulter is spreadman and Hank Scherer in charge of office at Eunice, Louisiana.

Company has also contracted two river crossings, Atchafalaya and Mississippi rivers, near Baton Rouge. M. E. "Panama" Williams is superintendent in charge of the crossings.

It's True! Lubricating Oils Are "Lazy" P 803.

Perhaps "lazy" is not a good name for them, but has it ever been brought to your attention that oil, water, milk, and other liquids have no ambition? They are continually searching for a lower level. Never a higher level. They do not voluntarily assist us.

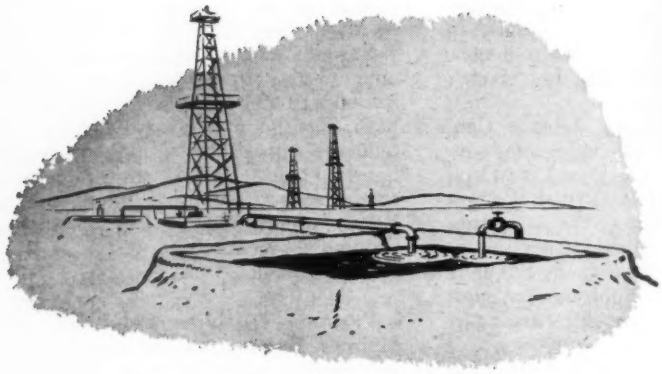
Take lubricating oil as an example. Oil won't run into a bearing of its own volition and do a good job of lubricating. It won't flow against friction in order to reach vital parts of the machine bearings. It must be put there one way or another.

As a result, the oil is forced to the vital spots by means of pumps, chains, rings, splashing, etc. The forced system of lubrication is more or less good, but it is not beyond criticism. It is not infallible. It must at least be given human attention. The very fact that the forced system of lubrication is good has too often been the cause of its neglect, and results have been disastrous.

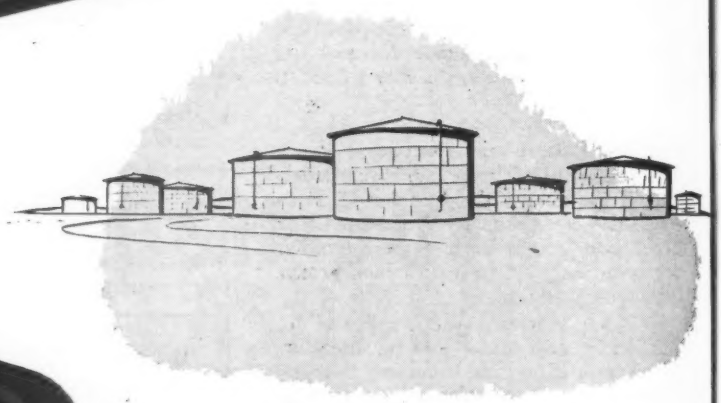
The user of the forced system of lubrication employing piping should see to it that the piping does not run in a haphazard way. It is not always sufficient to just "spill" oil on a bearing and let it go at that. Where the bearing is a large one, carrying considerable power, it is generally best to have the oil introduced at the center of the bearing where it is most needed. The oil will then flow outward toward the ends and thus lubricate the entire bearing surface.

In this connection it might be well to point out that there are really three distinct films between the shaft and the outer bearing of an ordinary journal. The first is the "outside film" which is constantly in contact with the rigid portion of the bearing and scarcely moves, if at all. The second is the "inside film" which makes contact with the rapidly revolving shaft or pin and moves at high speed as compared with the remainder of the lubricant in the bearing. The third is the "lubricating film," which is sandwiched between the first and second films and is in a constant state of shear, mixing, revolving, rubbing, and other torture and turmoil.—W.F.S.

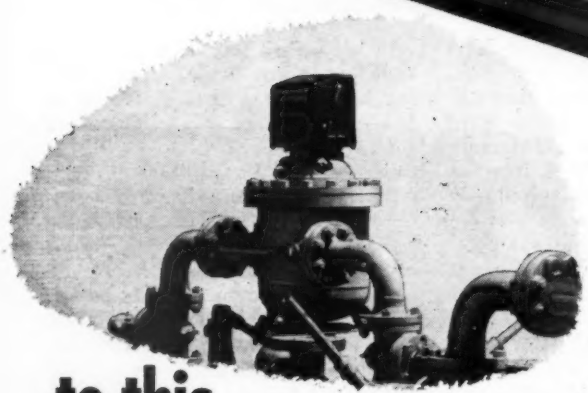
we've come a long way!...



from this In the early days of the petroleum industry, crude oil was stored in open pits. Measurement was "by guess or by gosh" and no consideration was given to evaporation loss.



to this With the increase in value of crude oils, conservation practices and accurate accounting of stocks became necessary. Two or more tanks were used for measurement and storage purposes.



to this Today, SMITHway Positive Displacement Rotary Meters combined with SMITHway *functional accessories* offer the ultimate in efficient pipe line operation. In addition to accurate measurement, they permit reduced tankage and real estate investment, increased thru-put with the same expense and reduction in idle inventory stocks. Write today for complete information.

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To obtain more information on products advertised see page E-45

Western Pipe Line Constructors, Inc., P. O. Box 798, Austin Texas, is completing 60 miles of 26 and 30-in. natural gas line near Lebanon and Moorehead, Kentucky, for Tennessee Gas Transmission Company. Two spreads are in operation on the job. At Lebanon Jack Hodges is superintendent, and A. G. Goyne, office manager, and at a field office at Greenup, Kentucky, Bennie Williams is superintendent and P. O. Rutledge, office manager.

Midwestern Constructors, Inc., 105 North Boulder, Tulsa 3, Oklahoma, is working on 97 miles of 30-in. pipe line between Cooks and St. Ignace, Michigan, for Lakehead Pipe Line Company. M. T. Wilhite is superintendent, John Work, spreadman, and A. T. Tolbert, office manager, at St. Ignace.

Construction has been completed on 75 per cent of the 2750-ft of 30-in. underwater crossing of the St. Clair River at International boundary between Sarnia and South Port Huron for Lakehead Pipe Line Company.

Work is progressing on a sub-contract for land work from Merritt-Chapman and Scott Corporation for two 20,000-ft 20-in. lines across Mackinac Straits, between Port LaBarbe and McGulpin Point, Michigan, for Lakehead.

Work is underway for Texas Illinois Pipe Line Company for station additions at Hoffman, Illinois, and construction of a compressor station at Hammond, Illinois. J. M. Graham is superintendent; W. D. Kaufman, office manager, and Doyle Cooper, engineer, at the Hoffman site. Ray M. Johnson is superintendent; W. C. Ryan, office manager, and Lonnie Dorman, engineer at the Hammond job.

Work on 153 miles of 16-in. line east side of Kalamazoo River in Michigan to Kennedy pump station at East Chicago, Indiana, is progressing. M. T. Wilhite is superintendent, John Petty, spreadman, and A. T. Tolbert, office manager. Office is at Battle Creek, Michigan.

R. B. Potashnick, Cape Girardeau, Missouri, is making progress on 101 miles of 10-in. pipe line for Standard Oil Company of Indiana. Job is between Colon and Romulus, Michigan. A. G. Hobson is superintendent and V. E. Connor office manager.

Pipe Line Construction and Drilling Company, Indiana, Pennsylvania, is working on 50 miles of 14-in. line for Buckeye Pipe Line Company between Allentown and Wilkes-Barre, Pennsylvania. Merrel Foudray is superintendent in charge and Fred Droddy office manager at Berlinsville, Pennsylvania.

Lyles and Young Company, P. O. Box 495, Avenal, California, is working on 136 miles of 8-in. line for Salt Lake Pipe Line Company, from Pasco to Spokane, Washington. Ronny Cook is superintendent, C. V. Miller, project manager, and C. E. Smith office manager.

Answering the telephone at their office, personnel of the Oklahoma Pipe Line Constructors in Dallas often find the full title a mouthful to say. To make it easier, they have shortened it to just plain "Oklahoma."

The phone rang recently. "Oklahoma," replied Oleta Leland. There was a pause.

"For goodness sakes," said the voice on the wire. "I was calling Dallas, Texas."

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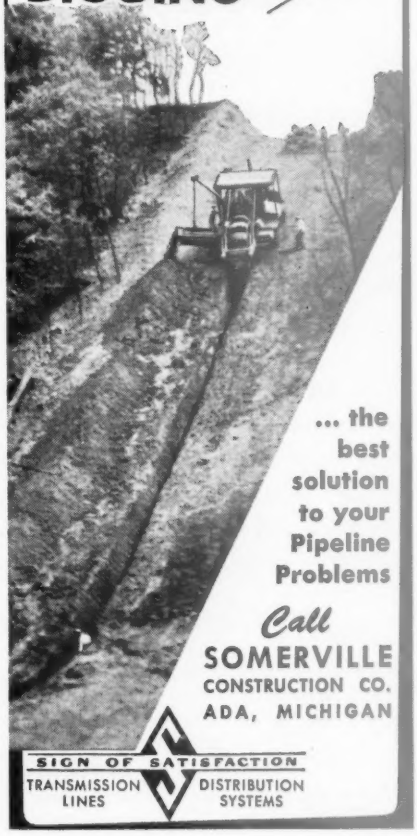

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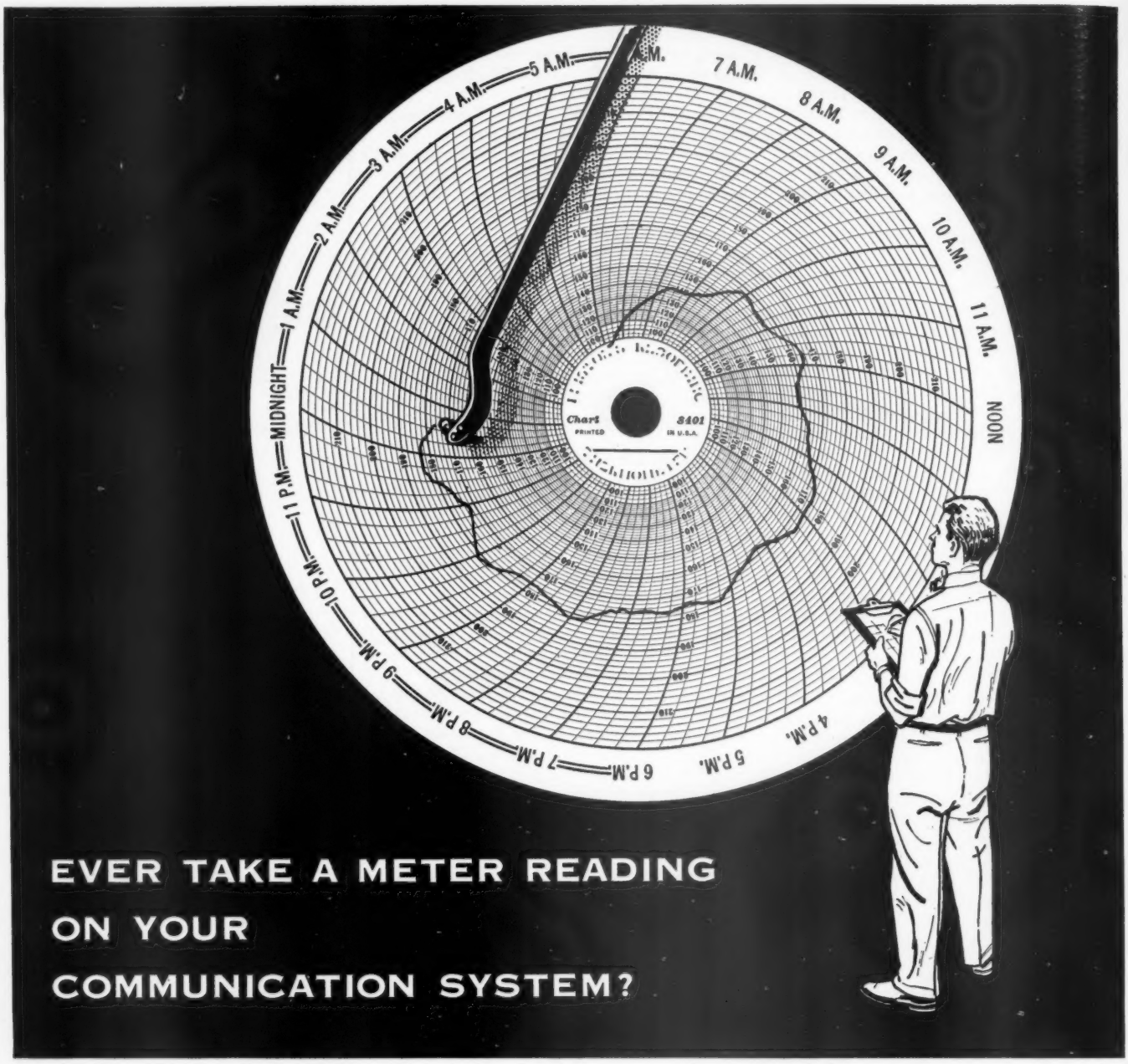

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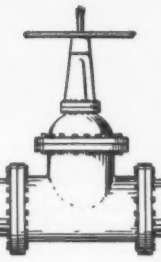
PIPE LINE PROJECTS



Magnolia to Build 154-Mile Texas Line

Magnolia Pipe Line Company will build 154 miles of new 16-in. pipe line from Ringgold, Texas, to Corsicana, according to L. H. True, president of the company. In addition, an all-electric main pipe line pump station at Ringgold will be constructed.

The new line will replace a multiple 8-in. line system and pumping equipment now in service and will carry crude oil from North Texas and Oklahoma oil producing areas. The 16-in. line will be the first big-inch pipe line laid by Magnolia since 1948 when the Dallas company completed its 647-mile, 20-in. line from Corsicana to Patoka, Illinois. The new Ringgold-Corsicana line will have the capacity to pump 80,000 bbl of crude oil a day into the Corsicana terminal.

Construction plans call for all modern pipe line features including metering equipment to measure incoming crude, motor operated gate valves, remote control tank gaging equipment, and a centralized control panel. All station lines will be installed above ground for easy maintenance and the Ringgold station will have two new 120,000-bbl storage tanks.

Kansas-Nebraska Seeks FPC Approval on New Line

Kansas-Nebraska Natural Gas Company, Inc., of Phillipsburg, Kansas, has filed an application with the Federal Power Commission requesting authority to construct a total of about 41 miles of pipe line and other related facilities on its natural gas transmission system in Kansas and Nebraska.

The proposed new sections of line would replace existing lines previously authorized by the FPC. The company also plans to install additional cooler and scrubber facilities at existing compressor stations, and to construct a new compressor station which would be powered by facilities to be salvaged from a station the company proposes to abandon.

Two New York Lines Okayed

Certificates have been issued by the FPC to two New York pipe line companies to construct and operate facilities to carry natural gas to new areas of New York state and increase deliveries to other sections now having service.

New York State Natural Gas Corporation, New York City, was authorized to construct and operate facilities at De Ruyter, New York.

Two permits were given New York State Electric and Gas Corporation of Ithaca, New York. One is for 49 miles of 8- and 10-in. pipe line which will bring natural gas to Madison, Chenango, and Otsego counties.

A second certificate authorizes construction of 9.5 miles of pipe line between Auburn and Seneca Falls, New York, and addition of two 1100 hp units at an existing compressor station in the Auburn area.

Cost of the facilities is estimated at $35,920 for New York State Natural and $2,650,000 for New York State Electric.

Colorado Expansion Gets FPC Approval

Colorado Interstate Gas Company, Colorado Springs, Colorado, has received FPC permission to construct pipe line facilities in Colorado, Oklahoma, Texas, and Kansas to increase sales capacity of its gas transmission system.

The project, estimated to cost $19,856,596, will increase the sales capacity of the company's Rocky Mountain system by 82,500,000 cu ft of natural gas per day, from the present capacity of 426,300,000 cu ft to 508,800,000 cu ft by the 1953-54 winter season.

Construction program includes 49 miles of 20-in. main line loop, and 18,920 hp at new or existing main line compressor stations. The project also includes a total of 35 miles of 12- and 16-in. pipe and 5940 hp in supply facilities, 37 miles of 8- and 16-in. sales laterals, and approximately 112 miles of 4- to 20-in. field pipe lines.

Rehearing Set on 13 Cases

The FPC has granted a rehearing on certain parts of an order issued May 1 in which it ruled on 13 applications by 10 companies, including eight Columbia Gas System, Inc., subsidiaries. The cases deal with pipe line projects and distribution facilities.

Iroquois to Develop Underground Storage

Iroquois Gas Corporation, Buffalo, New York, has been granted an FPC certificate to construct pipe line facilities in connection with the development of the Aurora field near Aurora and Colden, New York, as a storage area for natural gas.

The company will develop the Aurora field to an estimated capacity of approximately 1,600,000,000 cu ft of active gas and a base of 2,400,000,000 cu ft. About six miles of 16-in. pipe will be built from the storage field to a point at Wales, New York, where the system connects with Tennessee Gas Transmission Company facilities.

Storage Pool Link Authorized by FPC

The FPC has authorized United Fuel Gas Company, of Charleston, West Virginia, to construct about 18 miles of pipe line and a new compressor station to be used in connection with the operation of a new natural gas storage pool near Limestone in Wood and Wirt Counties, West Virginia.

The proposed 18-mile line will extend from a connection with an existing line in the company's storage pool X-59, near Ripley in Putnam County, West Virginia, to its storage pool X-58 in Limestone. The compressor station, which will contain three 880 hp units, each supercharged to 1100 hp will be situated in storage pool X-58.

Big Increases Seen By PAD'S Final Report

For the year ending July 1, the Petroleum Administration for Defense authorized 8319 miles of pipe line, 1511 miles of it from second-hand material or other material operators had in inventory.

Pipe line construction planned between now and the end of 1954 totals 4486 miles, the report said, bringing the total since mid-1952 to 12,805 miles. PAD also forecast an increase of 10,899,000 bbl of storage by end of 1954.

During a two-year period ending July 1, the PAD reports, operators completed 9355 miles of pipe line for crude oil and products operation. In the same period, operators also reported the completion of storage projects with a capacity of 35,365,218 bbl.

The statistics are from a final report by PAD's supply and transportation division. The reports are being discontinued because of the ending of the controlled materials plan.

Rehearing Granted South Georgia Request

The Federal Power Commission has granted a request by South Georgia Natural Gas Company, of Birmingham, Alabama, for rehearing of an FPC order issued May 4 denying the company's application to build a natural gas transmission system to serve markets in Georgia and Florida. The date and place of the rehearing will be fixed by further Commission order.

South Georgia is proposing to build 335 miles of pipe line extending southeasterly from a point on Southern Natural Gas Company's system in Lee County, Alabama, through southwestern Georgia and into Florida. Total cost of construction is estimated at $8,141,518.

Texas-California Line Approved for El Paso

Authorization has been granted El Paso Natural Gas Company of El Paso, Texas, to carry out a construction program that will increase the daily capacity of its pipe line system by about 400,000,000 cu ft to a total of 1,910,010,000 cu ft of natural gas per day for delivery to customers in Texas, New Mexico, Arizona, and California. Of the total volume, 1,421,210,000 cu ft will be for the California markets.

At the same time, the FPC issued certificates to Pacific Gas and Electric Company, San Francisco, and Southern California Gas Company and Southern Counties Gas Company, both of Los Angeles, authorizing them to construct facilities enabling them to transport the additional gas to be received from El Paso.

Total estimated cost of El Paso's project is $175,250,000, exclusive of financing costs and working capital. The construction program will include 1056 miles of pipe line and 161,860 hp in compressor capacity. The new facilities will permit delivery of an additional 300,000,000 cu ft per day from the Permian Basin and an additional 100,000,000 cu ft per day from the San Juan Basin.

The two Los Angeles companies were authorized to construct and operate jointly 73 miles of pipe that will partially loop their existing Blythe to Los Angeles line and 5280 hp in additional compressor capactiy. Cost of these facilities is estimated at $7,482,194.

Pacific Gas will construct a total of approximately 227 miles of pipe line and 2500 hp in additional compressor capacity. Estimated cost is $26,721,435.

El Paso asked the FPC to amend a certificate issued in June, 1952, to remove the restrictions imposed on its authorized San Juan and Permian Basin pipe line facilities, limiting the maximum daily delivery to a total of 550,000,000 cu ft to Pacific Gas and 555,000,000 cu ft to the Los Angeles companies.

The commission pointed out that the newly-authorized facilities will permit delivery of an additional 300,000,000 cu ft daily to Pacific Gas and to the Southern California companies and that any time one of the California customers takes less than the authorized amount, El Paso could increase the amount to be delivered to the other customer. The FPC said that as a result of the new authorizations it would not be necessary to further modify the 1952 certificate.

Williamson
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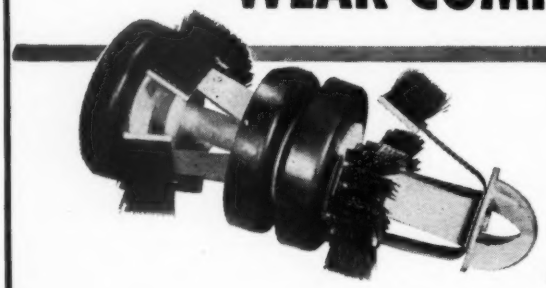

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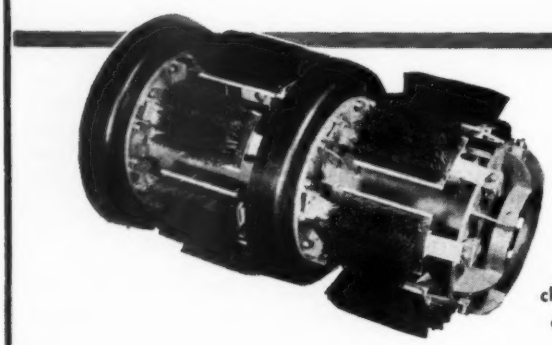

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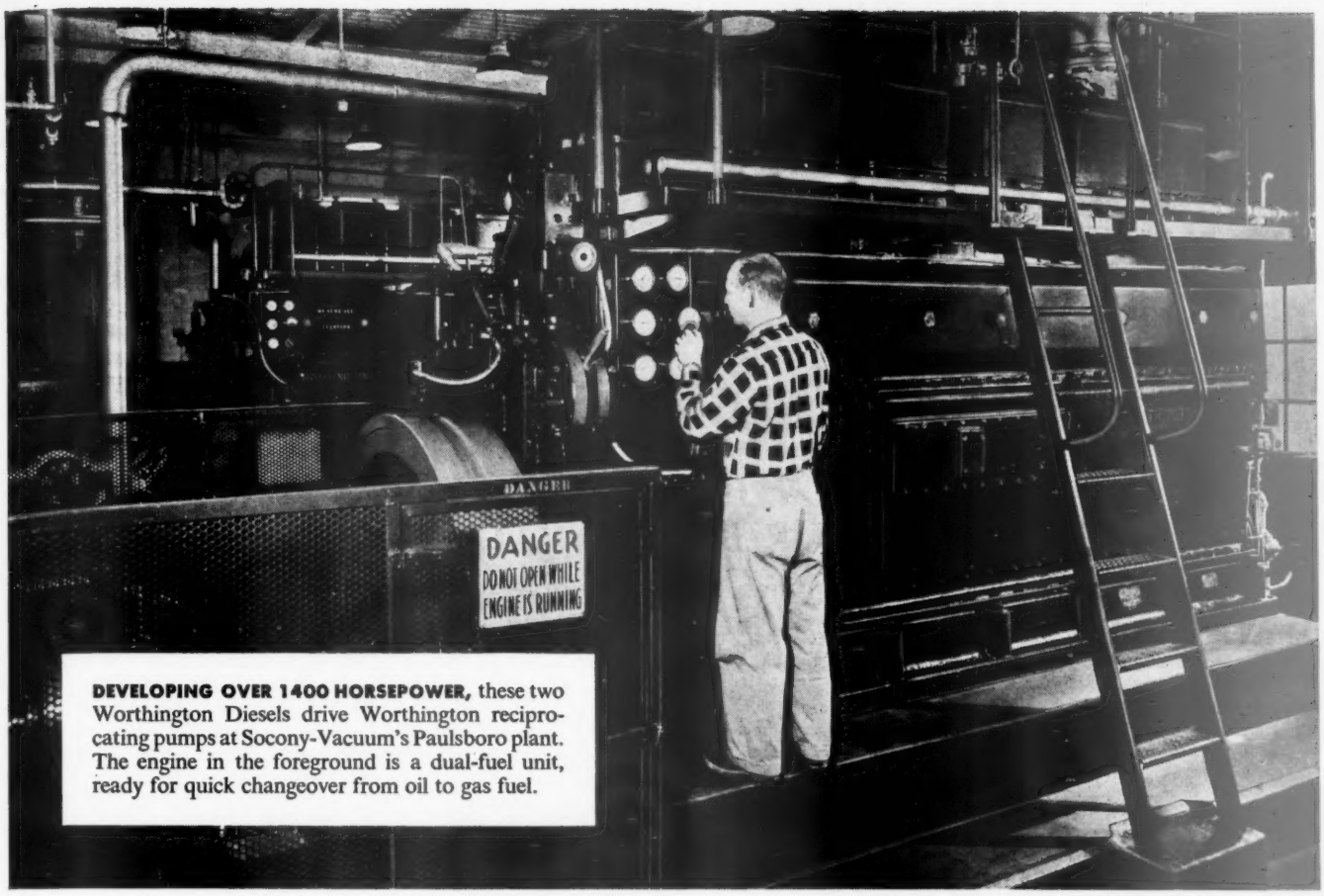
INTERSTATE'S Finney station will be hub of Louisiana net.

Interstate Plans New Hub Station

A modern crude oil pipe line pump station will be built by Interstate Oil Pipe Line Company near Shreveport to serve as the hub station of it's modernized and expanded Shreveport - Baton Rouge trunk line system. The new unit will be named Finney Station in honor of W. R. "Cap" Finney, former pipe line advisor for Standard Oil Company of New Jersey. Finney was Interstate's first president.

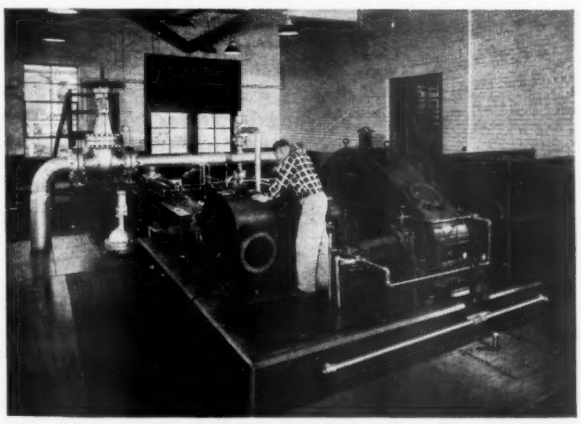
Completion of the station is planned for December, depending upon delivery of materials on schedule. Construction of station tanks, with a capacity of 815,000 bbl will take longer, company officials indicated.

Design capacity of the Shreveport-Baton Rouge line with the new station will be 133,000 bbl per day. Finney station will be equipped with three centrifugal pumps driven by 1500 hp electric motors, using weatherproof type equipment in an outdoors installation.



DEVELOPING OVER 1400 HORSEPOWER, these two Worthington Diesels drive Worthington reciprocating pumps at Socony-Vacuum's Paulsboro plant. The engine in the foreground is a dual-fuel unit, ready for quick changeover from oil to gas fuel.

Worthington Diesels power pumps along Socony-Vacuum line



DRIVING WORTHINGTON RECIPROCATING PUMPS like this one at the Paulsboro station is the job that Worthington engines along Socony's pipeline do with complete dependability. At the McCrea, Pa., booster station—midway along the line—continued pumping depends entirely on the driving power of a single Worthington Diesel, since no standby unit is used.

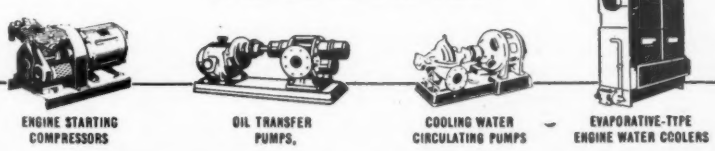
From their refinery at Paulsboro, New Jersey, through a booster station at McCrea, Pa., the Socony-Vacuum Oil Company pumps refined oil products across Pennsylvania to Pittsburgh.

Three Worthington Diesels—two at Paulsboro and one at McCrea—furnish all the power for driving the pumps on this 300-mile pipeline.

Socony-Vacuum's long, satisfactory experience with these dependable and efficient Worthington engines is duplicated by pipeline companies everywhere. Users know that when they buy Worthington dual-fuel Diesels they're getting the most for their dollar. The ability of the Worthington dual-fuel units to operate on crude oil from the line, Diesel oil, gas, or any combination of gas and oil, assures economical operation under all conditions.

Get all the facts on Worthington Diesels, dual-fuel or gas engines. Write to Worthington Corporation, Engine Division, Section E.3.4, Buffalo, N. Y. E.3.4

Worthington-Built Auxiliaries



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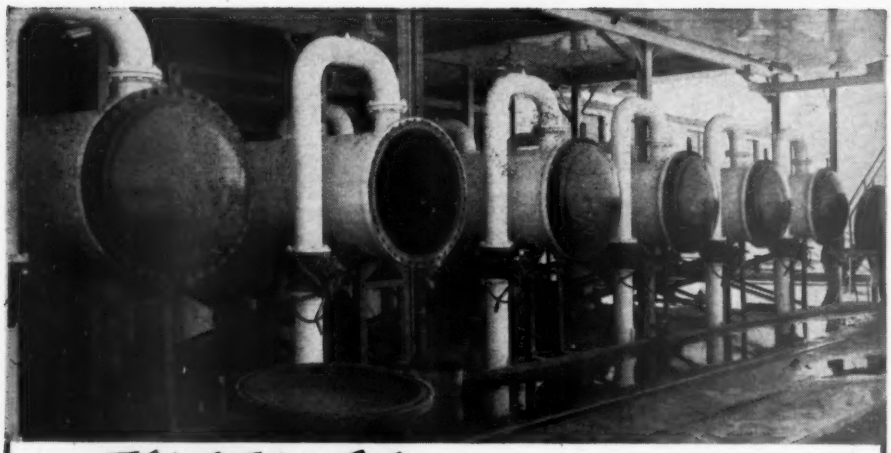

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. . . for removal of bulk quantities of water, pipe scale, and rouge from products Pipelines . . . . .

These HPQ-1000 SC Separators are in use at Plantation Pipe Line Company's Baton Rouge Pumping Station. Today, more and more Products Pipe Line Companies are using EXCEL-SO Units to remove water and dirt from products streams either as primary coalescers or as first-stage units in connection with desiccant dehydration.

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Onan PRODUCTS

Pipe Line Projects

Products Terminal To Be Constructed

Great Lakes Pipe Line Company's board of directors has authorized extension of the refined petroleum products carrier system to Grand Island, Nebraska, where a delivery terminal will be constructed.

Work will commence as soon as materials are available and the new terminal will probably be in operation late this fall, the company indicates. Great Lakes currently transports products from Oklahoma and Kansas refineries through its lines to 14 delivery terminals in seven midwest and north central states.

Replacement Line Slated by Humble

Approximately 40 miles of 18-in. pipe line, which will replace two existing 10-in. lines, will be constructed from Longview, Texas, to the Texas-Louisiana state line, Humble Pipe Line Company has announced.

Plans for the new line have been prepared and are ready to submit for bids. Construction is expected to be underway by August 15, company officials indicate. The line will connect with an Interstate Pipe Line Company line at the state line and will carry crude to Baton Rouge, Louisiana.

West Texas Line Contract Awarded

Texas-New Mexico Pipe Line Company has awarded a contract to McVean and Barlow, contractors of Odessa, Texas, to construct approximately 52½ miles of crude oil pipe line in West Texas.

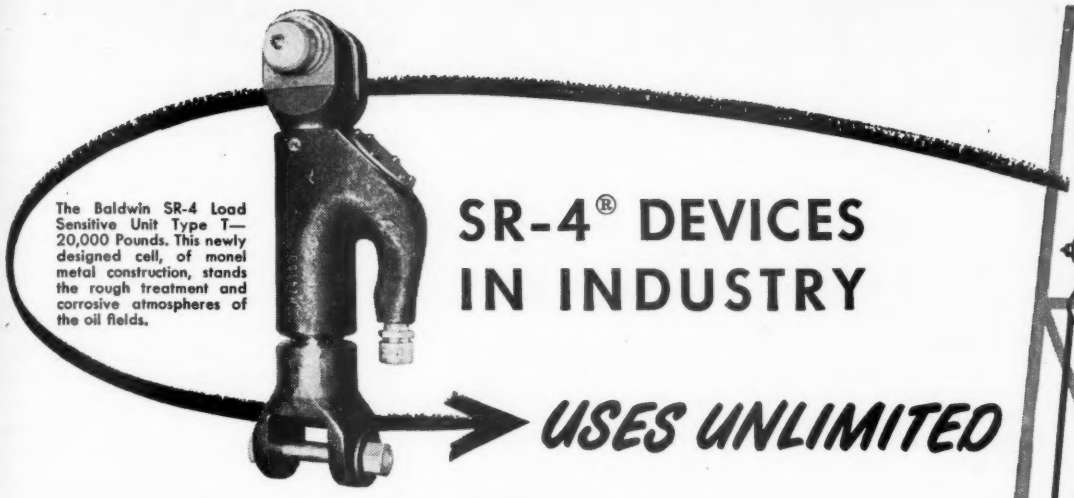
The 10¾-in. pipe line will extend from the Basin Pipeline System's Midland, Texas, station northward paralleling the company's 8- and 10-in. Midland-Sundown main line and terminating in Dawson County, Texas.

Salt Lake Line Plans Expansion

An expansion program providing for a 20 per cent increase in the capacity of the 566-mile petroleum products line from Salt Lake City, Utah, to Pasco, Washington, has been announced by J. T. Higgins, president of the Salt Lake Pipe Line Company.

Cost of the project, estimated at $1,700,000, will include a new pump station at Huntington, Oregon; additional pumps at the existing stations at Juniper, Idaho, and Baker, Oregon; 40 miles of additional 6-in. line between Adams, Oregon, and Pasco, Washington, and five 12,500 bbl tanks at Boise, Idaho.

After the installation of these facilities, Salt Lake Pipe Line Company, a wholly-owned subsidiary of Standard Oil Company of California, will have a capacity of 42,500 bbl per day from Salt Lake City to Boise, and 22,500 bbl per day from Boise to Pasco. Expansion is necessary to handle increased shipments from the Salt Lake City area.



The Baldwin SR-4 Load Sensitive Unit Type T—20,000 Pounds. This newly designed cell, of monel metal construction, stands the rough treatment and corrosive atmospheres of the oil fields.

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THE SCHLUMBERGER PROBLEM:

The Schlumberger Well Surveying Corporation of Houston, Texas, required a means of observing cable tension during the tests they conduct in oil well drilling operations. Equipment was subject to extremely rough treatment and highly corrosive conditions.

THE BALDWIN SOLUTION:

Specially designed Baldwin SR-4 Tension Links, hung between the top sheave and the derrick cap, measure the tension in the cable supporting the survey equipment being used in the hole. Baldwin SR-4 devices operate on the principle of the famous SR-4 bonded wire strain gage.

SCHLUMBERGER BENEFITS:

1. When lowering equipment, suddenly decreased tension indicates a hang-up of equipment in the hole. Saves time—insures accurate records.
2. While in the hole, a continuous rough indication of cable and tool weight gives the operator an additional protective check for smoothness of his survey operation.
3. When pulling equipment up, suddenly increased tension indicates equipment caught in the hole, allowing correction to avoid cable breakage and losing or damaging expensive instruments. Saves time—saves money.
4. In field use, corrosive conditions and rough treatment are easily withstood by this Baldwin SR-4 unit. Avoids costly down time.

Baldwin SR-4 devices have uses unlimited in industry—measuring load, fluid pressure, or torque economically, speedily, and accurately. For the latest technical information please write to Department 3330, Baldwin-Lima-Hamilton Corporation, Philadelphia 42, Pa.

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Pipe Line Projects

Pacific Northwest Gas Contracts Large Reserves

Contract for natural gas reserves in 202,000 acres in the San Juan Basin between Phillips Petroleum Corporation and Pacific Northwest Pipe Line Corporation of Houston has been extended, according to C. R. Williams, president of Pacific Northwest.

The pipe line firm has applied to the FPC for authorization to build a line from the San Juan Basin to the Pacific Northwest and to serve Colorado through the Colorado Interstate system.

Williams also said contracts had been made with General Petroleum Corporation for 35,000,000 cu ft per day reserves from in Rio Blanco county, Colorado, and Sublette County, Wyoming, which are adjacent to the route of the proposed pipe line.

Pipe Lines to Link Refineries in India

Award of a contract to Merritt-Chapman and Scott Corporation of New York City for construction of an extensive system of subaqueous and overland pipe lines to link two petroleum refineries now being built at Bombay, India, with an offshore marine terminal has been announced by the Bombay Port Trust.

The project, estimated to cost approximately $4,000,000, will be constructed by Merritt-Chapman and Scott Corporation of India, a subsidiary of M-C&S, in association with the Hindustan Construction Company, Ltd., of Bombay.

Major phase of the work will involve the construction of approximately 50 miles of pipe line to provide a network of seven lines between marine terminal piers off Butchers' Island, approximately 2½ miles offshore, and two refineries now being built on the outskirts of Bombay, one by Burmah-Shell and the other by the Standard-Vacuum Oil Company.

The seven lines will range from 9 to 24-in. They will be used to pump crude oil from tanker to refinery, to return the finished product to shipside, and to supply the tankers with water. Of the 262,000 feet of pipe line that will go into construction of the project, approximately 84,000 ft will be underwater.

14-Mile California Gas Line Requested

Southern Counties Gas Company of California, of Los Angeles, California, has filed an application with the Federal Power Commission requesting authority to construct a 14-mile pipe line that would be used to provide additional capacity to meet increasing demands in Orange County, California.

The proposed facilities, estimated to cost $879,962, would include about 72,000 feet of 24-in. pipe and 1000 feet of measuring facilities.

$4,700,000 Project Slated By Ohio Fuel Gas Company

Ohio Fuel Gas Company, a Columbia Gas System, Inc., subsidiary, has received FPC approval for $4,700,000 in construction projects, including 69 miles of pipe line and two additional compressor units at existing stations, all in Ohio.

The expanded facilities are needed to handle increased deliveries from a new 30-in. pipe line under construction by Gulf Interstate Gas Company of Houston. The pipe line projects include 39.8 miles of 20-in. line and 29 miles of 24-in. line. Two 1500-hp compressor units will be added to the Crawford station in Fairfield County, Ohio.

River Crossings On Evangeline Line

Contracts have been awarded by The Texas Pipe Line Company for the construction of 16-in. products pipe line crossings of the Mississippi River at Baton Rouge and the Atchafalaya River near Krotz Springs, Louisiana, as part of the Evangeline Products System.

The crossing jobs were let to Panama-Williams Corporation, Houston, and J. Ray McDermott Company, Inc., Harvey, Louisiana, jointly.

The Evangeline Products System pipe line extends from Port Arthur, Texas, to Baton Rouge, Louisiana.

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PIPE CUTTING AND BEVELING MACHINE
Cuts and Bevels Pipe FASTER, MORE ECONOMICALLY
Split horseshoe shaped gear permits machine to slip quickly over pipe. Fast operating snap chain fasteners hold it in place. A complete cut and bevel can be made in a 12 inch pipe in about two minutes.
You'll soon save several times the cost of the machine in labor, gas and transportation charges. H&M takes approximately one-half the labor and gas to make the cut as hand cutting and the work is all done in the field.
Bring this light (24 to 155 pounds) but durable machine to the pipe instead of moving the heavy pipe to the machine. Remember, H&M designs for SPEED and ECONOMY.
Shape Cutting Attachment for cutting the various shapes of pipe intersections.
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The real "pay-off" value of any tractor to its owner is how it measures up to the standards set by today's modern production methods.

To meet these needs, Allis-Chalmers started from scratch and built *a line of tractors with a future.* Thousands now have been tested and proved on the toughest proving ground of them all, actual jobs, and they have more than measured up to expectations. Owners have found that these tractors set new standards of performance . . . that they give greater output with less down time . . . plus more profit, whether pulling, pushing, digging or dozing. Operators have discovered new ease and comfort in operation, too; and mechanics say these are the easiest-to-service tractors that they have ever worked on.

Yes, the "family circle" of users of Allis-Chalmers tractors is growing constantly. Many users who bought their first Allis-Chalmers tractor only a few years ago now have fleets of them, and many others who operate only one or two tractors have become Allis-Chalmers boosters.

This acceptance is the springboard behind a big plant expansion at Springfield, Illinois, which will enable Allis-Chalmers to meet *your* future needs. See your nearby Allis-Chalmers dealer now for the inside facts on pace-setting tractors that measure up to modern production methods.

This 72-drawbar hp., 18,800-lb. HD-9 is making friends in every field because its power and weight make it ideal for dozens of today's jobs. And, operators can gain up to 25 percent more production on short dozing jobs because they can go from any forward to any reverse speed with just one shift

The 40 drawbar hp., 11,250-lb. HD-5 is a versatile jack-of-all-trades. With hydraulically controlled Tractor Shovel, it's useful for dozing and for loading trench padding; and its maneuverability makes it valuable for pulling supply carts and welding equipment, etc. along right-of-way.

From pioneering to final grading of right-of-way . . . wherever speed and volume are essential to the job, this big HD-15 has more than proved its worth. With 109 drawbar hp. and 27,850 lb. weight, it works quickly, efficiently with dozer, side boom or Tractor Shovel.

Here's the powerhouse of the pipeline — the Allis-Chalmers HD-20 with 20-ft. sideboom-cradling pipe. Torque converter drive makes it easy to synchronize tractor speeds with cleaning-priming and doping-wrapping machines. With 175 engine hp. and 41,000 lb. weight, the HD-20 is today's new yardstick of crawler tractor performance.

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Pipe Line Projects

Re-hearing Slated On Georgia Gas Lines

A consolidated hearing to commence August 17 in Washington, D. C., on applications by Chattahoochee Natural Gas Company and Southern Natural Gas Company, both of Birmingham, Alabama, proposing the construction of natural gas pipe line facilities in Georgia, has been scheduled by the FPC.

Chattahoochee is proposing to construct a 70-mile pipe line system to supply natural gas to four communities in northwest Georgia, and Southern Natural has requested authority to build a line tap and metering and regulating facilities to supply natural gas to Chattahoochee.

Chattahoochee's proposed system would connect with Southern Natural's facilities at a point near Rome, Georgia, and would serve Trion, Summerville, LaFayette and Dalton, Georgia, and the areas around those towns. Estimated cost of the facilities to be built by Chattahoochee is $1,510,828, and Southern's project is estimated to cost $31,000.

Houston Plans Additional Line

Houston Pipe Line Company has announced plans for construction of 50 miles of 24-in. main gas line between Edna and Wharton. Construction of the additional line is expected to start about September 1.

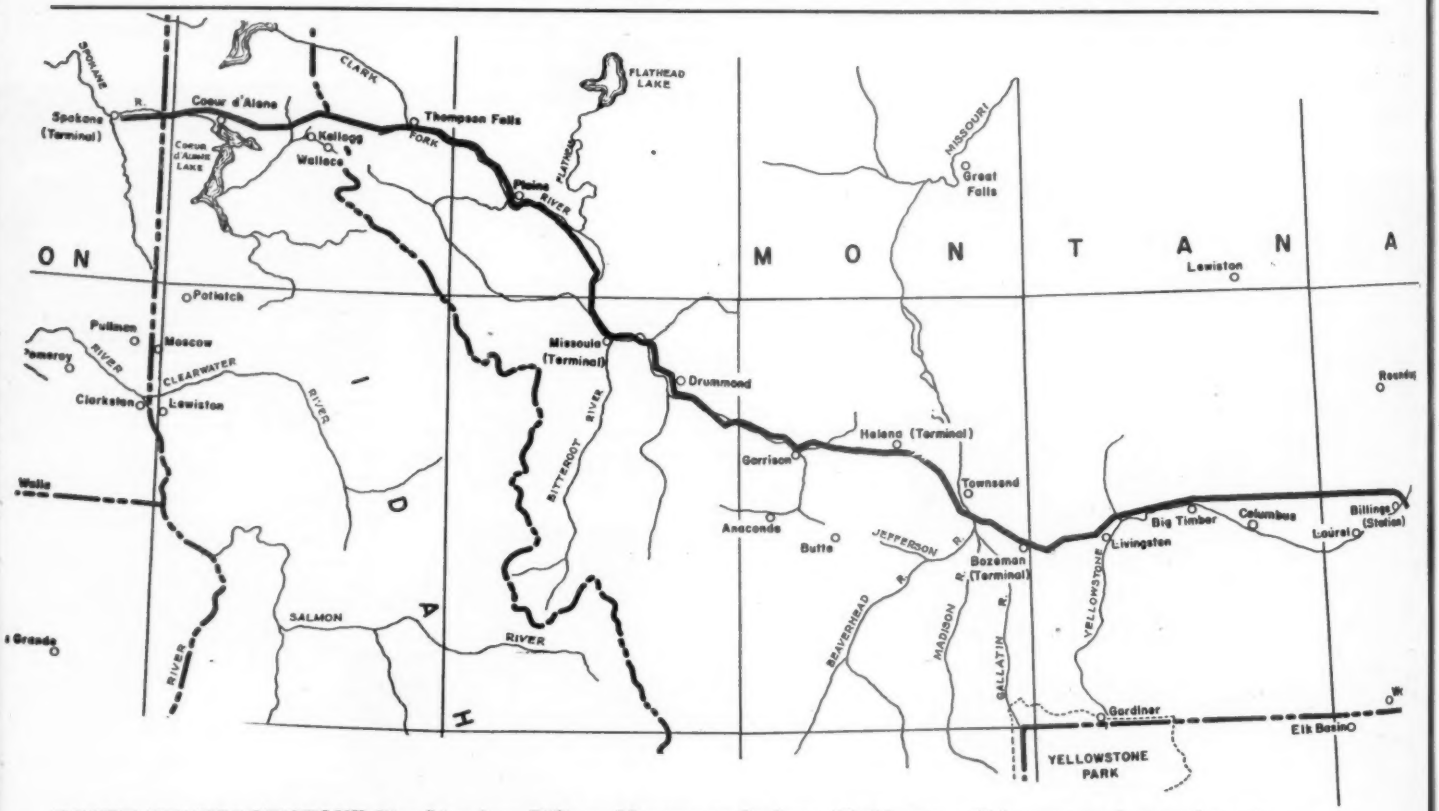
No compressor stations will be built on the line which is to be part of an existing high pressure system operated by the company.

Great Lakes Gas Line Permit to Be Asked

Authority to construct a 30-in. natural gas pipe line from Louisiana to markets in Michigan and Wisconsin will be applied for in the very near future, the Natural Gas Company has indicated.

Contracts for large reserves of natural gas in the Gulf Coast area of Louisiana have been signed with Stanolind Oil and Gas Company and with Superior Oil Company, William G. Woolfolk, chairman of Natural Gas has announced.

Markets for the company include Michigan Consolidated Gas Company, Milwaukee Gas Light Company and 14 other smaller utility companies in the two north central states.



ROUTE OF YELLOWSTONE Pipe Line from Billings, Montana, to Spokane, Washington, will be over much rugged terrain.

Four Companies to Share 540-Mile Yellowstone Line

Ownership of the new 540-mile Yellowstone pipe line from Billings, Montana, to Spokane, Washington, plans for which were revealed last fall by Continental Oil Company, will be shared by Continental, Interstate Oil Pipeline Company, Union Oil Company of California and the H. Earl Clack interests.

The $20,000,000 line will be built and operated by Yellowstone Pipe Line Company, in which Continental Oil Company and Interstate Oil Pipe Line Company, and affiliate of Standard Oil Company (New Jersey), each own a 40 per cent interest. Union Oil Company of California and the H. Earl Clack interests each hold a 10 per cent ownership.

Construction of the line will be directed by Continental Pipe Line Company, of Ponca City, Oklahoma, which will also direct operations through the staff of the newly formed Yellowstone Pipe Line Company.

The 10-in. pipe line will carry refined oil products from Conoco and Carter Oil Company refineries at Billings to consumers served by terminals at Bozeman, Helena and Missoula, Montana, and Spokane. Plans call for the line to be in limited operation by the end of 1953 with completion scheduled for the summer of 1954. Conoco and Carter terminals at Bozeman, Helena, Missoula and Spokane will be in operation late this year.

With an initial capacity of 30,000 bbl of gasolines, fuel oil and other products daily, the new Yellowstone line can be expanded to transport as much as 50,000 bbl a day by the addition of other stations. Its route, starting at Billings, will extend generally northwest, passing through or near Big Timber, Livingston, Bozeman, Three Forks, Helena, Garrison, Missoula, Ravalli and Thompson Falls, Montana, and Coeur D'Alene, Idaho, with its western terminus at Spokane.

Aerial surveys indicate that pipe line construction crews will encounter unusually difficult terrain in laying the Yellowstone line over mile-high passes in the rugged Rockies. One pass through which the line must be laid just west of Helena reaches a height of 6200 ft, and a second, near Thompson Falls, approaches a mile above sea level it was reported by Continental Oil Corporation.

Olin Purchases Gas System in Louisiana

Olin Industries, Inc., has purchased control of Interstate Natural Gas Company of Monroe, Louisiana, from Standard Oil Company of New Jersey, John M. Olin, president, has announced.

Olin now owns 770,000 shares or approximately 81 per cent of the 953,000 shares outstanding. The price paid for the stock purchased was $45 per share. This same price has been offered all other stockholders of Interstate, thus involving a total purchase price of $42,000,000.

In this transaction, Olin purchased Standard Oil's 54 per cent interest, American Republic Corporation's 5 per cent interest and Columbian Carbon Company's 15 per cent interest. It already owned 7 per cent of the stock through its acquisition last year of Frost Lumber Industries Incorporated.

Interstate was acquired to provide the company with a facility to explore and develop the mineral rights of 455,000 acres of land in east Texas, Arkansas, and Louisiana, acquired from Frost.

Interstate produces and transports natural gas from the Monroe gas fields to refineries in Baton Rouge over 870 miles of pipe lines. The company owns substantial gas reserves in the Monroe field and controls larger reserves through contracts with various producers.

Trans Mountain Readying Communications Services

Plans for the patrolling and maintenance of Trans Mountain Oil Pipeline are now in the final stages and the communication system for the project is scheduled for completion soon, according to H. H. Anderson, vice president and general manager.

The dispatching normally is to be done by telephone with teletype and radio available in periods of possible telephone service interruption.

The Canadian National Telegraphs has installed a special telephone circuit along the 718-mile route which it will lease to Trans Mountain for about $50,000 per year. Between Kamloops and Merritt the circuit will be supplied by the B. C. Telephone Company, and between Merritt and Hope it will be attached to poles of Canadian Pacific Telegraphs. In addition, teletype service will be leased from Canadian National Telegraphs at least during the initial period of operation.

Radio equipment is being installed and will cost nearly $200,000. Trans Mountain is being assigned two radio telephone frequency channels by the Federal Government. One will be in a medium frequency band, about 2600-2700 kc, and the other in a high frequency band, about 160-170 mc.

Experiments disclosed that the medium frequency radio telephones will penetrate the mountainous country traversed by the line where other lower or higher frequencies have proven completely inadequate or unreliable. The high frequency is especially adapted to mobile operations and to short-range communication between patrol and maintenance personnel.

Fixed stations serving both frequencies, with masts approximately 120 ft high, will be installed at nine locations: Edmonton, Edson, Jasper, Blue River, Black Pool, Kamloops, Brookmere, Hope, and Burnaby. About 24 motor vehicles will be equipped with transmitters and receivers to operate on both frequencies.

The radio telephones will be used for dispatching only in emergencies when land-line telephones and teletypes fail, a condition occasionally to be expected along the mountainous route. Normally the radio will be used only for patrol and maintenance.

Arrangements are being concluded for patrol of the pipeline by helicopter during the first winter of operation. To accomplish this, an aircraft will be stationed at Kamloops for emergency as well as weekly regular patrols. This service should reduce the patrol work required of the six maintenance crews that will be headquartered at strategic locations along the line.

Entertainment Committee For AGA Meet Named

Robert D. Lewis, Laclede Gas Company, St. Louis, has been appointed chairman of the convention entertainment committee of the American Gas Association. This committee will be responsible for organizing and presenting a program of general entertainment at the 1953 AGA annual convention in St. Louis, October 26, 27 and 28.

Other members of the committee are Paul C. Ford, The Gas Service Company, Independence, Missouri; M. J. Harper, Rockwell Manufacturing Company, New York, New York; Daniel E. Maloney, The East Ohio Gas Company, Cleveland, Ohio; Marc W. Pender, Magic Chef, Inc., St. Louis, Missouri; William D. Sweetman, The Peoples Gas, Light and Coke Company, Chicago, Illinois; Wilbur T. Trueblood, Jr., Magic Chef, Inc., St. Louis, Missouri; and Richard F. Mulligan, AGA, who will serve as secretary of the committee.

Sunray Starts Bay Wells Gas Deliveries

Sunray Oil Corporation has started gas deliveries to consumer pipe lines from the Mustang Island and Red Fish Bay fields in Nueces County, Texas.

The two fields, which lie about 3 to 3½ miles south-southeast of Aransas Pass and extend about 10 miles in a southerly direction in shallow inland bay waters, have been divided into four units where low temperature extraction (LTX) equipment is being installed to gather gas and distillate from the fields.

The first LTX unit—which utilizes a low temperature extraction process whereby natural energy is used to do the work of separating gas and distillate—started gas deliveries to United Gas Pipe Line Company on May 31. The first unit is closest to shore and is delivering about 8,000,000 cu ft of gas daily.

The 36-mile, 16-in. United Gas Pipe Line Company has a capacity of about 130,000,000 cu ft of natural gas daily from the new bay source. The completed line extends from a meter station near Ingleside to a connection with United's system near Refugio, Texas.

When the four units are completed within about 60 days, Sunray will be delivering about 40,000,000 cu ft of gas daily out of the two fields. The bay fields, on an average, yield from 20 to 25 bbl of distillate per million cubic feet of gas.

Besides its own production, Sunray will handle gas-distillate production in the two fields for seven other producing companies in the area.

Previous to the construction of the present gas gathering facilities in the two fields and the start of delivery for commercial use, there were 28 shut-in gas-distillate wells in the area. Some of the wells have been shut-in as long as two and one-half years.

Engineers have found in the development of natural gas and gas-distillate reserves in the Red Fish Bay field that one gas-distillate productive zone (No. 10) at 7200 ft, underlies the entire surface area of the field.

Gas Industry's 1952 Steel Requirements Below 1951 Usage

Steel requirements in the gas industry for large diameter pipe used in 1952 were down 31.6 per cent over usage of the preceding year. Only 1,182,000 tons of larger diameter pipe, 16 inches or larger, were used in 1952 compared with 1,728,000 tons used in 1951, figures of the American Gas Association show.

Steel requirements of the gas utility industry as a whole totaled only 1,723,000 tons for 1952, principally line pipe, a substantial reduction from the 2,396,000 tons of steel needed for the industry's construction program a year earlier, the AGA figures note.

Principal factors responsible for the decline were completion of a majority of large size pipe line projects that had been urgently needed; the 1952 steel strike which caused postponement of pipe line construction activity; abandonment of some expansion programs because of steel storages and concentration by the industry on ways to utilize more fully the existing pipe line facilities.

Total steel pipe used for field, gathering and transmission lines aggregated 1,379,000 tons, about 80 per cent of total industry usage, a significant decline from the previous year. In 1952, only 4,147 miles of pipe line were approved by the Federal Power Commission compared with 5,791 miles the previous year. Compression horsepower increased in 1952 from 426,400 to 588,100.

Industry expansion in 1952 fell short of original expectations, the AGA reports. Originally anticipated construction expenditures in 1952 indicated a program of $1,173,000. Presently available preliminary estimates put this figure at about $1,000,000, a decline of 14 per cent under capital outlays.

CLEANING, COATING, WRAPPING & RECONDITIONING

★

HOT DOPE

Straight from the Kettle

on PIPE PROTECTION

★

By Boyd Mayes

We lost a job not long ago to an outfit who told the customer the reason for their low bid was that they "were so poor they *had* to get the job to stay in business." Funny thing, some people's idea of economy today. If the job was done right the bidder couldn't do anything but get poorer at the figure bid. If the low bidder made money on the job then the customer got nipped. It's no disgrace to be poor. We remember the time when we could hear about everything but bacon frying and dollars jingling, but we also remember . . . back in the horse and buggy days . . . that "it took the silver wheel to make the mare go," and we've never yet bid on a $20,000 contract with a pumpkin rind full of pennies to work with. We've probably been as poor as the leanest of them, but after 25 years of steady work, honest dealings, and country-boy luck, we have 71 acres of land to work on, an enormous amount of "paid for" equipment and a "million dollars" worth of skilled workmen on the job to deliver . . . in toto . . . *all* promises we make with our bids!

MAYES BROS.

1180 McCarty HOUSTON, TEXAS OR chard 7546

Pipe Line News

AGA Officer Slate Ready for Convention

The general nominating committee of the American Gas Association has drawn upon the executive talent of member companies throughout the United States and Canada for its slate of officers, directors and section chairmen for the association for submission at the AGA annual convention. Association officers, section chairmen and vice-chairmen will be elected for the 1953-1954 year and directors will be elected for two-year terms expiring in 1955. The slate of nominees includes top executives of manufactured, natural and mixed gas companies as well as pipeline and utility holding companies. Manufacturers of gas appliances and equipment are included in the list of candidates.

Nominees will be voted upon by the membership at the 1953 AGA annual convention, St. Louis, October 26-28. The general nominating committee presenting the slate was elected at the 1952 AGA annual convention in Atlantic City, New Jersey. It comprises: F. A. Lydecker, Public Service Electric & Gas Company, Newark, New Jersey, chairman; James S. Moulton, Pacific Gas and Electric Company, San Francisco; Robert E. Ramsay, New Haven Gas Light Company, Connecticut; Willard F. Rockwell, Jr., Rockwell Manufacturing Company, Pittsburgh; Harry K. Wrench, Minneapolis Gas Company, Minnesota; C. H. Zachry, Southern Union Gas Company, Dallas, and H. Carl Wolf, AGA, secretary.

Offices to be filled include those of president, two vice presidents, a treasurer, 15 directors and 11 section chairmen and vice-chairmen. The following list of nominations is brought to the attention of the membership of the American Gas Association, in accordance with provisions of the Association's by-laws:

For president: Earl H. Eacker, president, Boston Consolidated Gas Company, Boston, Massachusetts.

For first vice president: F. M. Banks, president and general manager, Southern California Gas Company, Los Angeles, California.

For sceond vice president: Dean H. Mitchell, president, Northern Indiana Public Service Company, Hammond, Indiana.

For treasurer: Vincent T. Miles, treasurer, Long Island Lighting Company, Mineola, New York.

For director, two year term, expiring, October, 1955: M. A. Abernathy*, vice-president, United Gas Pipeline Company, Shreveport, Louisiana; B. C. Adams*, president, The Gas Service Company, Kansas City, Missouri; L. L. Baxter*, president, Arkansas Western Gas Company, Fayetteville, Arkansas; Frank Austin Brownie, president, The Canadian Western Natural Gas Company, Ltd., Calgary, Alberta, Canada; Sheldon Coleman, president, The Coleman Company, Inc., Wichita, Kansas; H. C. Cummins, first vice president, Northern States Power Company, Minneapolis, Minnesota; J. F. Donnelly, vice president in charge of sales, Servel, Inc., Evansville, Indiana; John E. Heyke, Jr., vice president, The Brooklyn Union Gas Company, Brooklyn, New York; J. K. Horton*, president, Pacific Public Service Company, San Francisco, California; D. E. Karn, president, Consumers Power Company, Jackson, Michigan; W. H. Ligon, president, Nashville Gas Company, Nashville, Tennessee; A. W. Lundstrum, president, Ohio Fuel Gas Company, Columbus, Ohio; F. T. Parks, vice president in charge of operations, Public Service Company of Colorado, Denver, Colorado; L. B. Richards, vice president, Harrisburg Gas Division, The United Gas Improvement Company, Harrisburg, Pennsylvania; and J. Theodore Wolfe*, executive vice president, Consolidated Gas Electric Light and Power Company, Baltimore, Maryland.

Accounting Section. For chairman: Paul E. Ewers, commercial office manager, Michigan Consolidated Gas Company, Detroit, Michigan. For vice chairman: A. T. Gardner, vice president and secretary, Delaware Power & Light Company, Wilmington, Delaware.

Industrial and Commercial Gas Section. For chairman: Charles C. Eeles, district industrial sales manager, The Ohio Fuel Gas Company, Toledo, Ohio. For vice chairman: Ray Trowbridge, commercial and industrial sales manager, Seattle Gas Company, Seattle, Washington.

Operating Section. For chairman: Frederick J. Pfluke, superintendent of gas operations, Rochester Gas & Electric Corporation, Rochester, New York. For vice chairman: W. H. Davidson, vice president, Transcontinental Gas Pipe Line Corporation, Houston, Texas. For second vice chairman: J. H. Collins, general superintendent-gas department, New Orleans Public Service, Inc., New Orleans, Louisiana.

Residential Gas Section. For chairman: Raymond Little, general sales manager, Equitable Gas Company Pittsburgh, Pennsylvania. For vice chairman: Walter H. Kurdelski, residential sales manager, Michigan Consolidated Gas Company, Grand Rapids, Michigan.

General Management Section. For chairman: Lovett C. Peters, financial vice president, Laclede Gas Company, St. Louis, Missouri. For vice chairman: Howard B. Noyes, vice president, Washington Gas Light Company, Washington, D. C.

*Re-nominated.

Republic's Gathering Lines Sold to Northern Natural

Northern Natural Gas Company has purchased the well-gas gathering system in Morton and Stevens counties, Kansas, owned by Republic Natural Gas Company, for $3,415,839, Republic president W. H. Wildes has announced.

Northern will use the pipe line system to gather gas into its own main line system from 213 Republic-owned wells. The purchase includes easement, right-of-way, permit, licenses, well-gathering pipe line, main gas pipe line, field station, and other gathering equipment.

PARSONS 215 *cross-country* TRENCHLINER

Pipeline Specialist

With its many special features for oil field operation, Parsons 215 wheel-type Trenchliner easily sets a "mile-a-day" pace on cross-country transmission lines, feeder and gathering lines. For instance . . .

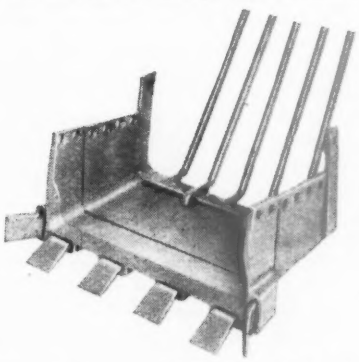
6 digging wheel speeds (up to 11.2 r.p.m.) and 30 digging feeds (up to 18 ft. per min.) give maximum trench production at every width, depth, and in all soil conditions.

Heavy-duty digging wheel, equipped with square or round-bottom buckets, cuts 13 to 31 inches wide, and 6 feet deep. Wheel responds instantly to friction-clutch control, holds accurate grade. Dual-purpose friction clutch drives the digging wheel, and acts as an automatic safety to protect against shock loads.

Standard tractor-type crawlers have 18-inch treads and lug-type shoes. They're self-cleaning . . . provide plenty of digging traction on grades and soft-footing. Ground-bearing pressure is only 6 lbs. per square inch.

Diesel powered . . . with a choice of 2 popular oil field diesel engines (55 h.p.) this special 215 Trenchliner fits right in with other equipment in your pipeline spread. Operation and maintenance are simplified.

Your Parsons distributor has more information on this 215 Trenchliner that will interest you. See him soon. 5 other Parsons models include wheel and ladder types, full crawler mounted, and a rubber-tired utility Trenchmobile®.



Easy-in, easy-out "Tap-In" teeth fit into sockets on buckets, side cutters and adaptors. They are inserted in less than a minute . . . interchangeable to any position. Self-sharpening. Installed on all Trenchliner models.

Send to: PARSONS COMPANY, NEWTON, IOWA
for information on 215 Trenchliner.

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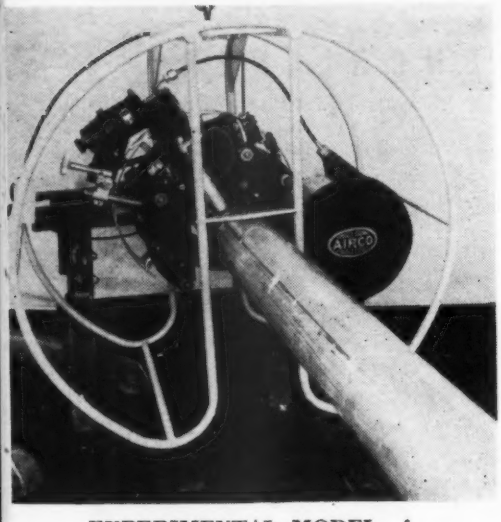
COMPANY ..... DIV. .....
STREET .....
CITY ..... STATE P367PE

PARSONS (Koehring Subsidiary) Trenchliners®

To obtain more information on products advertised see page E-45



EXPERIMENTAL MODEL of aluminum pipe welding machine.

Aluminum Pipe Welder Shown at AWS Meet

An experimental model of a special aluminum pipe welding machine was demonstrated at the American Welding Society exhibition in Houston, Texas, recently.

Developed by Air Reduction in cooperation with the Reynolds Metal Company engineering department, the machine is designed for the field welding of aluminum gas gathering lines and oil transmission lines. A consumable aluminum wire is fed by guide rollers from a reel to the welding nozzle. At this point, the wire, weld and base metal are protected from oxidation by a shield of inert-gas (argon, helium or a mixture of the two). A wind shield around the nozzle insures complete gas shield for welding out-of-doors.

The welding machine is constructed of cast aluminum, weighs approximately 200 lb and measures 4 ft in diameter by 2½ ft in width. A lifting eye is provided for raising and lowering the unit over the work. Once the machine is clamped to the pipe the welding gun circles it by means of a motor driven worm gear. Adjustments are provided to accommodate 4, 6 and 8-in. OD piping with wall thicknesses of ⅛ to ¼-in.

One push button simultaneously starts shielding gas flow, wire feed, circumferential movement of machine and arc. At the completion of the weld the machine stops automatically. A weld on 6-in. OD aluminum piping is made in 17 seconds.

10th NACE Program Planning Underway

Nine symposia have been arranged and some conference officials have been named by F. L. Whitney, Jr., of Monsanto Chemical Company, St. Louis, chairman of the technical program committee for the tenth annual conference and exhibition of the National Association of Corrosion Engineers to be held at Kansas City next March 15-19.

H. L. Bilhartz of the Atlantic Refining Company, Dallas, will serve as co-chairman of the National Association of Corrosion Engineers Kansas City meeting. He will be chairman of the 11th annual meeting in Chicago in March 1955.

A. D. Simpson, Jr., United Gas Corporation, Houston, will be chairman of the pipe line coatings symposium; N. K. Senatoroff, Southern Counties Gas Company, Los Angeles, chairman of the protective coatings symposium; R. C. Buchan, Humble Oil and Refining Company, Houston, oil and gas production symposium chairman, and E. H. Tandy, Standard Oil Company of California, El Segundo, refinery industry symposium chairman.

Corrosion Short Course Planned

A four-day short course on corrosion will be given September 22-25 at Texas A&M College, covering corrosion fundamentals, materials of construction, coatings, cathodic protection, instrumentation, and special topics:

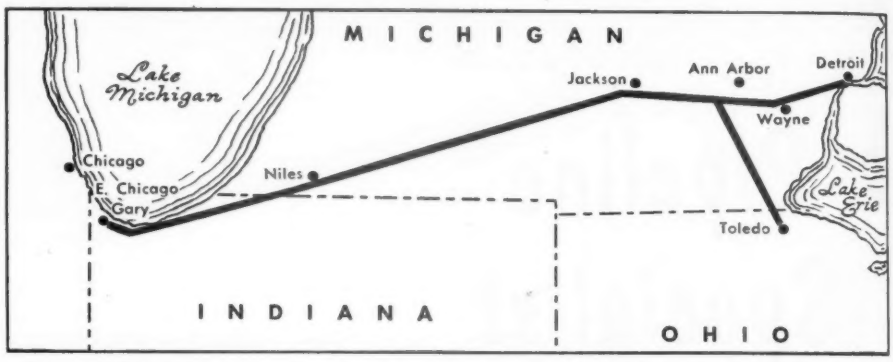
Additional information may be obtained from J. D. Lindsay, chemical engineering department, Texas A&M College, College Station, Texas.

Rapid Tax Write-Off Given Augusta Pipe Line

Federal tax write-offs allowing deduction of a percentage of construction costs from federal tax bills in 5 years instead of 20 have been granted Augusta Pipe Line Company, Houston. These include a 40 per cent write-off on $155,000 products pipe line and a 25 per cent write-off on $1,043,000 products pipe line.

FPC Rehearing Granted To Panhandle Eastern

The FPC has granted a request by Panhandle Eastern Pipe Line Company, of Kansas City, Missouri, for rehearing of an order issued April 22 which affirmed, with modification a decision by a presiding examiner authorizing Panhandle to operate pipe line facilities built by Indiana Gas and Water Company, Inc., of Indianapolis, Indiana, and to sell other facilities to the latter company, and directing Panhandle to eliminate the unlawful discrimination found to exist with respect to its natural gas deliveries to Indiana Gas. The date and place of the rehearing will be fixed by further order, the Commission said.



MAP SHOWS ROUTE of new 16-in. products pipe line being built by Wolverine Pipe Line Company. Fifty miles of line is being coated with Somastic, while Hevicote is being used on 5.3 miles.

Price to Coat Products Line

Contract covering the application of Somastic coating to approximately 50 miles of the new 16-in. line and a concrete jacket of Hevicote to 5.3 miles of pipe for the recently organized Wolverine Pipe Line Company has been awarded to the H. C. Price Company of Bartlesville, Oklahoma.

Somastic will be used on sections of the new products pipe line through heavily congested areas of East Chicago and Gary, Indiana, and across swamps in lower Michigan. Route of the new line is between East Chicago and Detroit, with a lateral extending south to Toledo. Shell Oil Company, Cities Service Oil Company and the Texas Company are sponsoring the Wolverine Pipe.

Coating specifications call for application of a 9/16-in. Somastic to approximately 50 miles of 16-in. line pipe, with a one-inch application of Hevicote to 5.3 miles of pipe. Montie J. Lane, Price's east coast Somastic division manager, is supervising the project.

Desert Center Station Gets Second Test, Adjustments

Operation of the Desert Center compressor station on Southern California Gas Company's Texas-California line has begun, and addition of the Cactus City station upon completion in early August is expected.

Adjustments in the intake and discharge piping of the gas turbine engine and compressor unit, were completed in July at the Desert Center station and the equipment was given a "shake down run" before being added to the line.

Completion of the booster stations at Desert Center and Cactus City will raise capacity of the pipe line to 530,000,000 cu ft per day.

Work on the Blythe compressor plant No. 2 is underway with Ofcco Construction Company installing machinery and piping. Apex Steel Corporation is erecting the building. A gas cooling tower for the plant has been completed.

Addition at the Blythe station, of two 1760-hp compressors will bring line capacity to 555,000,000 cu ft per day.

Pipe Line Patrol Flies 4,000,000th Mile

A pipe line patrol plane of Gleason Romans Aviation, Inc. recently flew the company's 4,000,000th mile, officials announce.

Although patrolling pipe lines by airplanes was started by Shell in 1938, Gleason Romans was the first company to contract this work. Starting in 1945 with three planes and three pilots, Gleason Romans now uses 12 specially equipped planes operating from eight bases. With a force of 18 pilots, the company offers emergency service in addition to regular duties. All the planes are equipped with two-way radios and with other special equipment developed by the company. The company now flies 18,000 miles of pipe line a week. In 1945 the average mileage per week was 3500.

The contract pipe line patrol of several interconnecting pipe line companies' lines forms a circuitous route, eliminating wasted flying time. The efficiency of larger flight operation also makes possible lower cost to the pipe line companies.

Aerial patrol was first used for the emergency location of pipe line leaks. One of the big uses now is in preventive maintenance and protection of right-of-way.

Color Movie Shows Houston's Progress

"Partners in Progress," a 20-minute color movie portraying the operation, construction and planning of natural gas pipe lines, has been prepared by the Houston Pipe Line Company for showing in communities served by the company.

The film relates the progress of the past 18 months of the Houston company and shows an entire sequence of planning, engineering, construction and operations phases. Field work, rights-of-way clearing, river crossings, installation and other construction work in natural gas pipelining are illustrated.

New Firm Formed For Canadian Line

Formation of Sun-Canadian Pipe Line Company, Ltd., to construct and operate an 8-inch, 200-mile products pipe line from Sarnia to Toronto, Canada, has been announced by Joseph N. Pew, Jr., president of Sun Oil Company, Ltd., and W. Harold Rea, president of Canadian Oil Companies, Ltd.

The pipe line will be jointly owned, two-thirds by Sun Oil and one-third by Canadian Oil. Main offices will be at London, Ontario. Construction of the pipe line was announced several months ago by Sun Oil Company, Ltd. and has since become a joint venture of the two companies.

William C. Kinsolving, president of the Sun Pipe Line Company, wholly owned subsidiary of Sun Oil Company, Philadelphia, will serve as president of the new corporation. Board of directors of the new company will include Clarence H. Tew and Douglas Robinson, both of Canadian Oil Companies, Ltd., and John C. Agnew of Sun Oil Company, Birney K. Morse of Sun Pipe Line Company and John Blair Moffet, Sun Oil Company general counsel.

Construction of the Sarnia - Toronto line is scheduled for completion about October 1. Estimated cost is approximately $6,000,000. Initial maximum capacity will be 17,500 bbl a day with a single pumping station at Sarnia.

Maximum capacity, with addition of extra pumping stations, will be 35,000 bbl a day. The line will connect with Sun Oil Company's new Sarnia refinery, also scheduled for completion on October 1, and the Canadian Oil Companies' refinery at Sarnia. The line will provide a year-round outlet at Hamilton, London and Toronto and eliminates dependence on Great Lakes transportation that becomes ice-bound in winter.

Teletype and radio-phones will be used in line communications. The line will be coated and have cathodic protection. Williams Brothers, a Canadian firm, is constructing the line.

Trans Mountain Ahead of Schedule

Operation of Trans Mountain Oil Pipe Line Company's 718-mile oil pipe line from Edmonton to Vancouver will begin a month sooner than expected if present construction pace is maintained, company officials have indicated. Flow of oil through the line will probably begin in September, instead of October as indicated in previous reports.

Progress on the 24-in. line has been good despite wet weather in parts of British Columbia and Alberta. By the end of June, 575 miles of pipe had been welded in place, according to Canadian Bechtel, Ltd., agents for design and construction of the line.

Hydrostatic tests with pressures 25 per cent higher than operating pressure have been completed on nearly 300 miles of the line. Permit to operate the line will be requested from the Board of Transport Commissions as soon as the complete line is tested.

Work at the Burnaby tank farm and Westridge deep sea loading terminal is following schedules and the facilities are to be completed before oil begins arriving in Vancouver.

Construction of the line is being done by 26 firms and Trans Mountain, with 2400 workers on the job.

First Cathodic Protection Study

The first short course offered by an American university on Cathodic Protection will be presented October 12-16 at the University of Illinois, Urbana. The National Association of Corrosion Engineers is cooperating with the university in presenting the course. Prof. Ray Wainwright of the university electrical engineering staff is coordinating the project.

Sessions will cover practical information useful to operating and engineering personnel, and enrollment is limited to 50 persons. All instructors at the short course are members of NACE.

107-Mile, 22-Inch Line To Begin in August

Construction of approximately 107 miles of 22-inch crude oil pipe line between Shreveport and Baton Rouge for Interstate Oil Pipe Line Company is expected to start in August.

Contract for the job has been awarded to River Construction Corporation, Fort Worth, Texas. The project will get under way as soon as pipe deliveries begin. Completion is expected by October 15, assuming that pipe deliveries are made on schedule.

The new large-diameter line is part of Interstate's program for modernizing and increasing the capacity of its Shreveport-Baton Rouge trunk line system, portions of which have been in service since 1910.

Contractors have just completed a 28-mile section of new 22-inch line extending southward from the site of the company's Finney pump station situated approximately 8 miles south of Shreveport. The additional 107 miles will complete the replacement of all of the multiple 8-inch lines and most of the dual 12-inch lines which Interstate now has in service on this system.

Plans call for two spreads to begin work as soon as pipe is received. One crew will start at a point about 5 miles northwest of Coushatta, in Red River Parish, and will lay southward toward Baton Rouge.

The second spread will start at a point near Erwinville, in Pointe Coupee Parish, and will lay northward toward Shreveport, to connect with spread Number 1.

Interstate Starts Work On New Pump Station

Plans for a modern pump station to replace the old Weller pump station in Claiborne Parish, about 10 miles west of Homer, Louisiana, have been announced by Interstate Oil Pipe Line Company.

Preliminary grading and foundation work is already in progress and completion of the station is scheduled by November 30, pending receipt of materials.

The new Weller station will be equipped with three centrifugal pump units, each driven by a 400 hp high speed, dual fuel engine. Numerous automatic and safety controls will be installed at the station. Housing the pumping equipment will be a shed type building, a portion of which will be enclosed to provide a station office, an office for the station chief engineer and warehouse space.

In designing the station, consideration was given to the corrosive "sour" crudes from south Arkansas fields which the station will pump. Protection against sour crude corrosion is to be provided, in part, by applying a coating of plastic to the inside of the station lines and manifold. Six 55,000 bbl tanks now in service will be retained at the station. They are already lined with concrete as a preventive measure against internal corrosion. The other four tanks will be retired upon completion of new station.

Pipe Line Personals

Watt H. McBrayer, Angus A. Davidson, and **Earl W. Unruh** have received promotions from the Sinclair Pipe Line Company. McBrayer, former counsel for Sinclair, has entered the executive department of the company as assistant to the president. Davidson, who has been associate counsel and part interest executive, will assume charge of Sinclair's legal department as counsel. Unruh, who has been chief general engineer of the pipe line company, has been named part interest executive in charge of various joint ventures and part interest pipe line systems in which Sinclair participates.

H. Vinton Potter, former coordinator of promotion, has been named coordinator of both promotion and advertising for the AGA under a unification program. **Clifford E. Hall** has been appointed promotion manager and **Norval D. Jennings** named advertising manager for the AGA.

F. E. Coyle, Tide Water Associated Oil Company, has been appointed president of the Western Pipe Liners Club for the 1953-54 year. **L. E. Joses,** Standard Oil Company is the group's new vice president and **C. W. House,** General Petroleum Corporation, secretary-treasurer.

Named to the club's membership committee were **N. F. Anderson,** Richfield Oil Corporation; **J. H. Robinson,** Union Oil Company; **W. C. Roberts,** Shell Oil Company; **E. L. Dreyer,** The Texas Company; **Joses; House,** and **Coyle.**

Entertainment committee members will include **D. F. Purdy,** Richfield Oil Corporation; **M. C. Alcorn,** Shell Oil Company; **A. S. Joy,** Bechtel Corporation; **D. C. Frame,** The Texas Company; **W. W. Mitchell,** Tide Water Associated Oil Company; **E. F. Hudson,** Standard Oil Company; **Kenneth Ford,** Sunray; **W. M. Conley,** Union Oil Company, and **E. B. Saunders,** Standard Oil Company.

Serving on the nominating committee will be **J. B. Pate,** Union Oil Company, **R. K. Paine,** Standard Oil Company; **W. C. Roberts,** Shell Oil Company, and **G. H. Supple,** General Petroleum.

Mark D. White has been appointed superintendent of Skelly Oil Company's pipe line department in Kansas, succeeding the late **George E. Ault.** White will be stationed at El Dorado, Kansas.

W. F. Davis, native Kentuckian and a civil engineer, has been appointed assistant general manager of Interstate Oil Pipe Line Company, Shreveport, Louisiana. Davis, former assistant to the general manager, will assist vice president and general manager **Bruce Ramsey** in the company's overall operations. He began his career in pipelining in 1942 with the Oklahoma Pipe Line Company, Interstate predecessor, at St. Elmo, Illinois. He subsequently served in Tulsa, Mississippi and Montana, returning to Tulsa when Interstate succeeded the Oklahoma line. In 1950, he was on loan to Lakehead Pipe Line Company as manager of that company, returning to Interstate in 1951 as assistant to the general manager until his recent promotion.

New director of Interstate is **Carl G. Herrington,** Tulsa, director and manager of the Carter Oil Company production department. Herrington, a native of Tecumseh, Oklahoma, is a civil engineer, who began his oil career as a roustabout with Carter at Crescent, Oklahoma. He is a 1934 graduate of Oklahoma A&M college, Stillwater.

Claude L. Draper, of Wyoming, has been unanimously elected vice chairman of the Federal Power Commission to serve during the remainder of the calendar year 1953. He succeeds former commissioner **Harrington Wimberly** whose term as a member recently expired.

Draper has been a member of the FPC since 1930, and in point of service is the dean of the commission. Originally appointed by President Hoover in 1930 when the commission was reorganized with five full-time members, he was reappointed for five year terms by Presidents Hoover, Roosevelt and Truman.

He served as vice chairman of the FPC from July 1, 1939, to December 31, 1941, and again during the calendar year 1949.

L. B. Bonnett, vice president of Consolidated Edison Company of New York, Inc., has been named chairman of the AGA's 1953 distinguished service award committee. Other committee members named include **J. J. Hedrick,** president Natural Gas Pipeline Company of America, Chicago, Illinois, and **C. H. Zachry,** president of Southern Union Gas Company, Dallas, Texas.

Lyle R. Sheppard of Shell Pipe Line Corporation, Houston, has been named chairman of the technical practices subcommittee of the National Association of Corrosion Engineers, on problems of electrical holiday inspection of coatings. The committee membership is currently outlining a course of action on such problems as holiday inspection of pipe coatings before burial, after burial and coatings on tank bottoms.

James S. Phillips, who has been vice president in charge of purchasing and business promotion for the Columbia Gas System Service Corporation, has been elected vice president and general manager of the firm's Charleston group of seven companies. Phillips joined the firm in 1929 after graduating from West Virginia University. He was with Ohio Fuel from 1932 to 1946 and in 1949 was elected vice president of the CGSSC. During world war II he served with the air force for three and one-half years.

Charles W. Person, "Mr. Gas Advertising," has retired as advertising director of the American Gas Association after 34 years service with the organization. First secretary of the AGA's publicity and advertising section, he helped launch the advertising and promotion programs of the industry. He was also instrumental in forming the Public Utilities Advertising association.

A native Nebraskan, he spent 19 years in Denver, Colorado. After a year's study at the University of Colorado, he entered Columbia University in New York and was graduated in 1912 with a BS degree. He worked as a reporter until the first world war, where he served abroad. In 1919, he joined the AGA. Except for a four year period spent in producing employee educational courses, he has been a member of the AGA headquarters staff, actively engaged in advertising and publicity work.

As director of advertising he has been secretary for 17 years of the national advertising committee. During his tenure, he served under the administration of 27 AGA presidents and three managing directors.

C. M. Floyd, Sublette compressor station superintendent for Northern Natural Gas Company, has been named superintendent of both compressor station and gasoline plant facilities at the Sublette site. **Dale Kullbom,** assistant superintendent at Bushton, has been named superintendent of the Hugoton compressor station and **James Hinzman,** master mechanic at Bushton, for Northern Natural Gas, has been named to Kullbom's former position.

Pipe Line News Briefs:

Exchange Oil Purchasing Corporation, Dallas, has offered to purchase all state-owned oil produced in West Texas for shipment to California via the proposed West Coast Pipe Line Company. A $2500 option to buy the oil has been offered the state. The company, in conjunction with the pipe line firm, also offered a 2 per cent bonus over market price for all crude taken into the line, which is expected to be completed in two years.

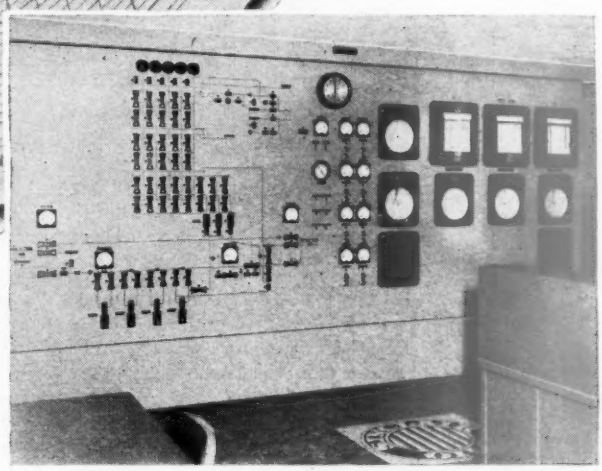
Houston Texas Gas and Oil Company, which proposes a 2300-mile natural gas system to transmit gas from Texas and Louisiana to points in Michigan, Pennsylvania, and New York, has elected four members to its board of directors. They are R. C. Cockburn, Cockburn Oil Corporation; Glenn McCarthy, independent producer; L. S. Cage, banker and independent operator, and Charles M. Rogers, New Orleans gas expert. Application to the Federal Power Commission is expected shortly for permit to construct the new facilities. J. S. Marks is president of the company. Frank R. Smith is special Louisiana representative.

Here's 1 Controller that holds 2 related variables within set limits

The NEW FOXBORO M-40 AUTO-SELECTOR

This Unique Controller operates from two related measurements automatically transferring control from one to another as required to prevent either one from exceeding its set limit. As in the case diagramed at right, when supply is greater than demand, control is maintained on the demand side (discharge) . . . but when demand exceeds supply control is maintained on the supply side (suction).

The M-40 Auto-Selector has two measuring elements and control mechanisms — also a combined air relay. It actually does the work of two instruments . . . with one or the other variable under control at all times. The transfer of control from one variable to the other is smooth, instantaneous, and with no upset. Any type of control action may be used. Any combination of related variables may be controlled - pressure and flow; temperature and level; two flows; two pressures; etc.



SINCLAIR PIPE LINE COMPANY'S new 670 mile, 22-24 inch line from Cushing, Okla., to East Chicago is operated by all-Foxboro control instrumentation, based on the unique Auto-Selector Controller. Above: part of control panel at Cushing Station.

Write for details. The Foxboro Company, 648 Neponset Ave., Foxboro, Mass., U.S.A.

FOXBORO
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RECORDING · CONTROLLING · INDICATING
INSTRUMENTS

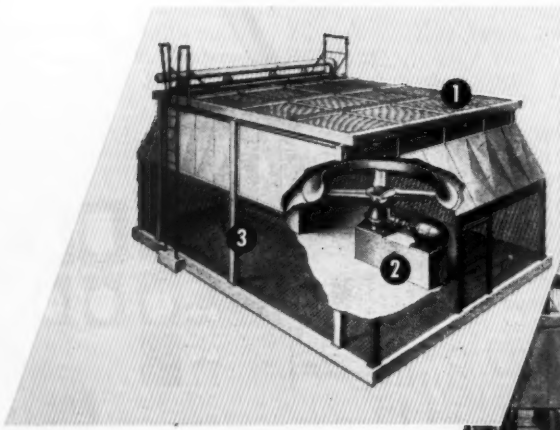
For low cost

waste heat removal

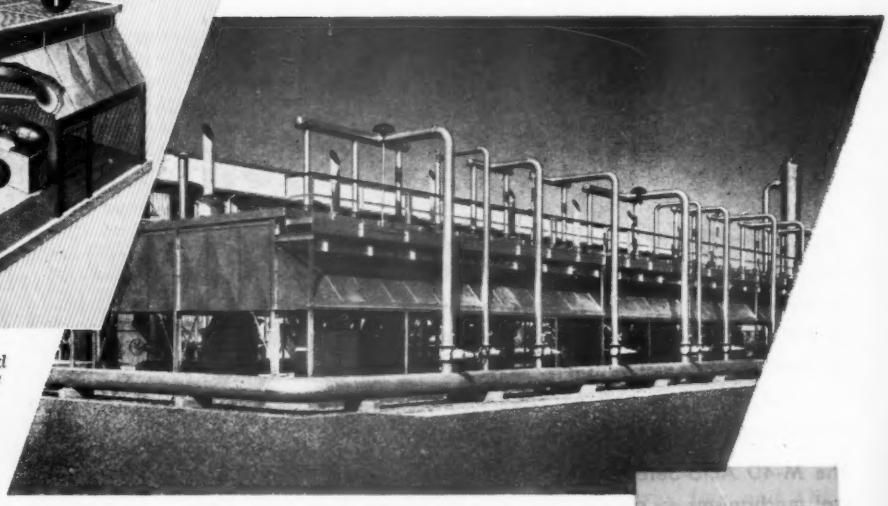
investigate **Fluor Fin-Fan!**

For economical dissipation of heat loads from liquids and gases, the Fluor Fin-Fan air-cooled heat exchanger is your answer. It is highly versatile, adaptable to a wide range of duties and capacities, serves in any climate independent of wind and water conditions, and is designed for any cooling requirement where final fluid temperature is higher than dry bulb air temperature.

Fluor Fin-Fans are used in a multitude of applications on gas transmission lines, in petroleum refineries, light hydrocarbon processing plants, chemical processing plants, power and related industrial plants of many descriptions. They are designed for cooling services involving pressures up to 5000 psi and at temperatures to 1500° F. The Fluor Fin-Fan is the ultimate in simplicity, structurally and mechanically. Each unit is individually sized for each heat transfer problem and can be single pass or multi-pass, single cell or multi-cell, connected in series for long temperature ranges, in parallel for large capacities, or in combinations to best suit the cooling need.



A Fluor Fin-Fan consists of three simplified components: (1) The new improved Transaire heat transfer surface that provides greater cooling at no increase in horsepower. (2) Independently-mounted fan, gear and driver located at ground level for easy maintenance. (3) Steel structure completely prefabricated for easy field erection.



Gas cooling at a compressor station on a Texas pipeline.

Write today for a copy of our new illustrated booklet describing the Fluor Fin-Fan in detail—Bulletin FF-FD-0.001.

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To obtain more information on products advertised see page E-45

Keep Heat Transfer Surfaces CLEAN...

SPECIFY

Vogt

SCRAPED SURFACE *Exchangers*

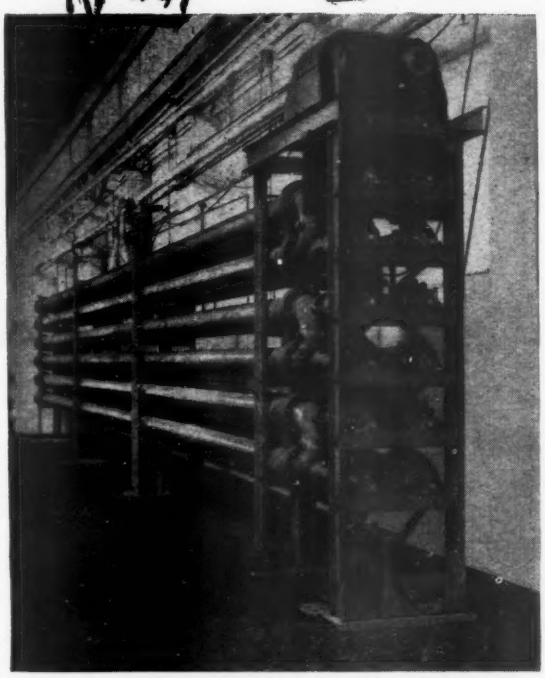
IF you are all "gummed up" with a tough heat transfer problem, Vogt Scraped Surface Exchangers will provide the answer. They have patented scraper elements which prevent fouling of the heat transfer surfaces and insure the highest rate of heat exchange between the product and the cooling or heating medium. The scrapers also continuously agitate the fluid and assist removal of solids from the unit.

DOUBLE PIPE EQUIPMENT is available in two types; EXCHANGERS, for cooling with water, brine, and cold filtrate, and for heating with steam or hot liquids; and CHILLERS, for use with volatile refrigerants such as ammonia, propane, and Freon. Both types have 8" jacket pipes and 6" inner pipes with scrapers.

SHELL AND PIPE TYPE UNITS are designed for use with volatile refrigerants and for heating fluids with steam or similar heating mediums. They consist of large welded shells each containing seven 6" scraped pipe sections.

Vogt Scraped Surface Exchangers serve profitably as oil chillers, crystallizers, and heaters in many processes in the petroleum and chemical industries. Their application to your heat transfer problems will receive the prompt attention of our Engineering staff.

Write for Bulletin PE-1



*DOUBLE PIPE UNIT. Drive end close-up of 12 section unit under test in our shop.

*SHELL and PIPE UNITS. Two of five units installed in a leading petroleum refinery.

*Patented

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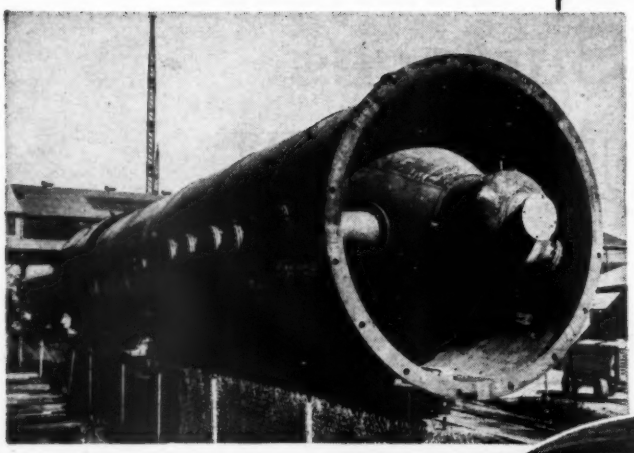
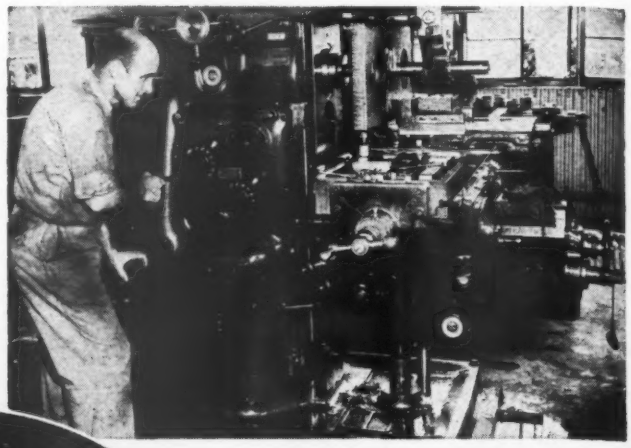
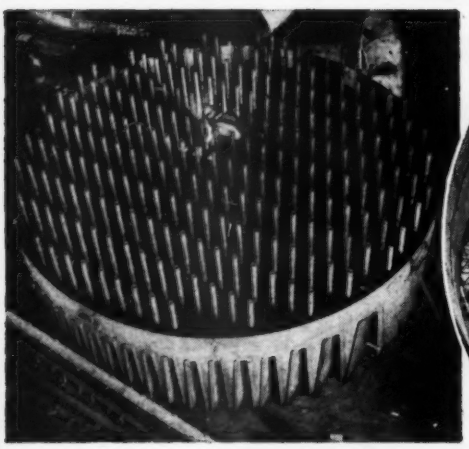
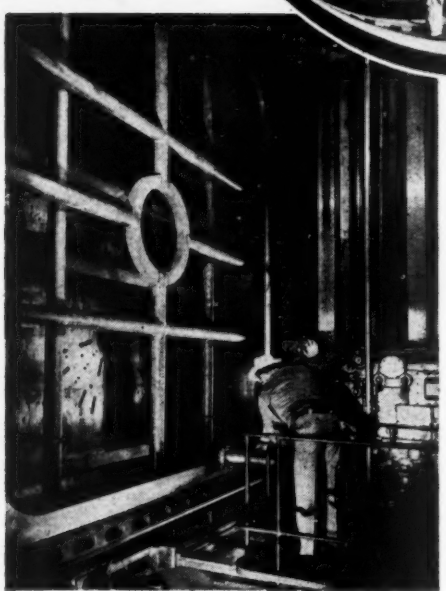
The Fine Art of Doing Things Well

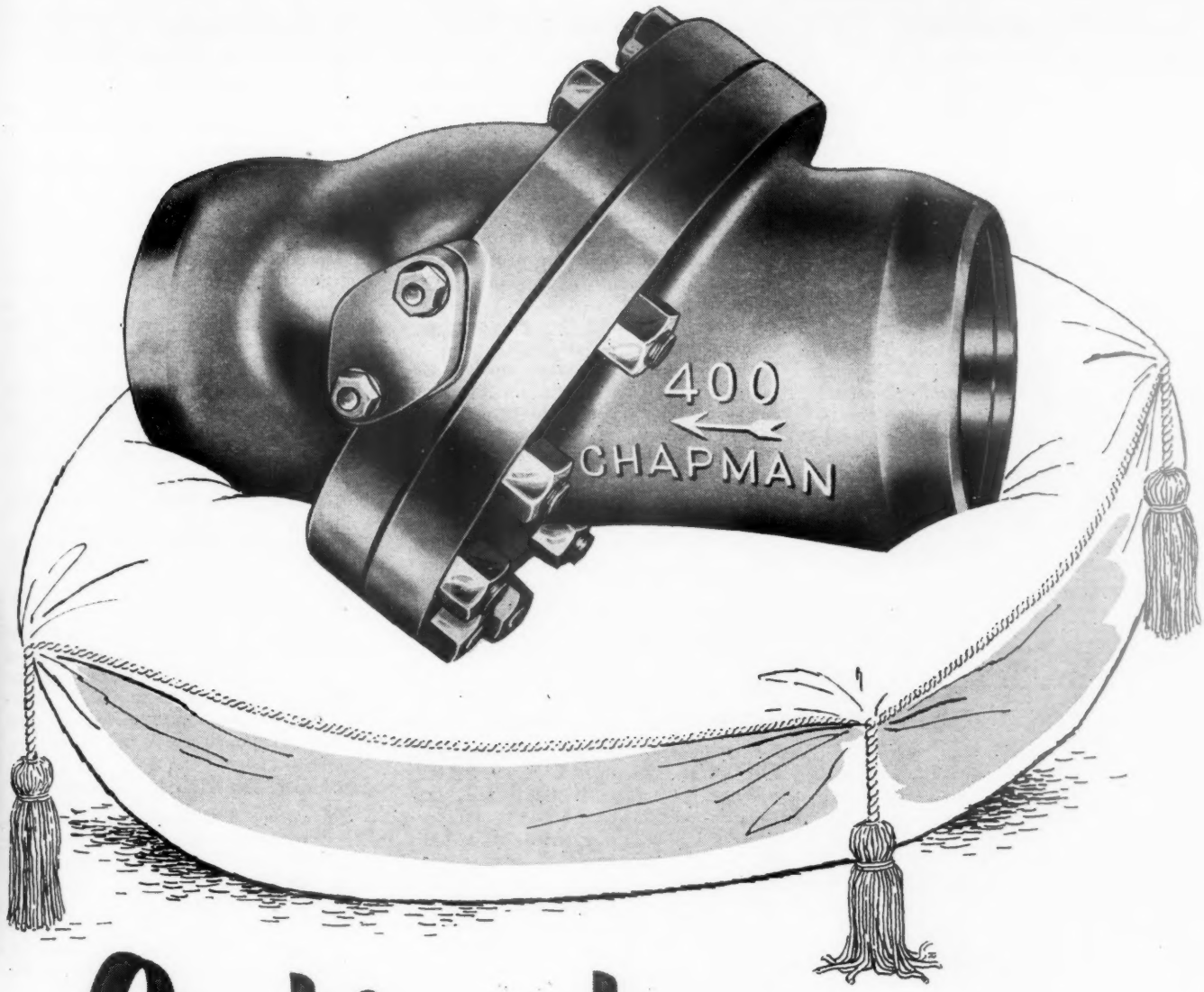








MANUFACTURERS AND ERECTORS SINCE 1913



Cushioned

to a drop-tight seat...

... that's why these unique

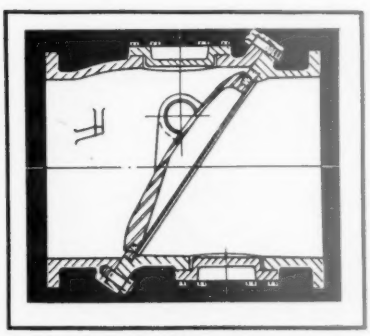
CHAPMAN

***Tilting Disc* CHECK VALVES**

cut head-loss to lowest levels

The Chapman Valve Mfg. Co.

INDIAN ORCHARD, MASSACHUSETTS



Here's what Chapman means by "Cushioning:"

This specially designed, "air-foil" disc balances perfectly in open position . . . then drops easily to closed position (cushioned by the flow). No jarring or slamming, in usual pipe-layouts. Write for bulletin.

CHAPMAN TILTING DISC **CHECK VALVES**

Oil Price Increase May Affect Proposed Import Law

Recent oil price hikes are expected to lessen chances of an oil law limiting oil imports. Russell B. Brown, counsel, Independent Petroleum Association of America, said the price increase would "undoubtedly lessen the pressure for immediate legislative action on the imports problem." He added, however, that price increase did not remove necessity for long-range solution of the problem.

One independent oil man in Washington denounced timing of price rise, though not the rise, and said it came at a time when the House was preparing a vote for or against import legislation.

In connection with imports, the American Petroleum Institute reported total imports for the week ending July 11 were 920,300 bbl per day. Imports for the week before, July 4, were also under the 1,000,000 mark of June 27, when they totaled 1,039,700 bbl daily.

Below are the last four weeks figures as reported by API:

Week ended	Crude oil	Residual oil	Distillate fuel oil, asphalt, others	U. S. total
June 13...	723,100	330,900	5,000	1,123,900
June 20...	557,500	206,000	30,200	936,000
June 27...	613,900	231,100	13,600	1,062,000
July 4.....	369,700	274,100	5,000	716,800
July 11....	592,600	295,800	14,700	966,200

The Petroleum Administration for Defense has issued below the final summary of oil products exported from the U. S. Publication of summaries was begun in October, 1951.

	Avgas	Motor gasoline	Kerosine	Distillate	Residual	Total
May 22...	35.9	42.3	....	127.3	37.4	237.9
May 29...	33.2	25.1	15.9	83.6	49.3	207.1
June 5....	35.9	11.9	18.7	45.6	37.9	150.0
June 12...	27.8	36.9	33.7	88.1	59.6	246.1

Series was ended for two reasons, PAD reported: 1. Practically complete recovery from effects of Iranian production shutdown of June, 1951, has made PAD figures, which were more nearly current than any others available, less significant for industry operations than they were earlier. 2. Reductions in staff of PAD made compilation and publications more difficult.

Eight Cargoes of Oil Land From Iran Since July 1951

Following table gives legal decisions made by Anglo Iranian up to the end of June on cargoes of oil from Iran. Eight cargoes, aggregating 62,090 tons, had then been landed, compared with 54,000,000 tons exported from Iran by the company during the preceding two-year period, according to the company.

Three legal decisions have been handed down, with the company's claim to ownership of cargoes upheld in one.

Tanker	To	Arrived	Port	Tons
Rose Mary....	Italy	June 1952	Aden	790
Miriella.....	Italy	Feb. 1953	Venice	4,600
Alba.....	Italy	April 1953	Leghorn	10,000
Miriella.....	Italy	April 1953	Venice	4,600
Pax.....	Italy	May 1953	Venice	4,500
Alba.....	Italy	May 1953	Venice	10,350
Brezza.....	Italy	May 1953	Leghorn	10,150
Nissyo Maru...	Japan	May 1953	Kawasaki	17,100
Total.....				62,090

Abandoned Slate Pits May Serve for Storage of Oil

Plans looking toward the adaptation of abandoned slate pits in northeastern Pennsylvania as underground reservoirs for the seasonal storage of home heating oil are being considered by Esso.

The project, the first of its kind in his country, although the principle has been applied elsewhere, was described by William Naden, vice president in charge of manufacturing, as having tremendous possibilities for the petroleum industry in meeting the growing seasonal nature of operations.

The company has taken options on 11 slate quarries or pits in the Pen Argyl section near Bethlehem which have a total potential capacity of 13,000,000 bbl of heating oil. This is equivalent to the seasonal heating requirements of more than 325,000 average homes. The pits range in dimensions from 100 to 300 ft deep, 200 to 500 ft long and 140 to 270 ft wide. Except for suitable protective roofing and other necessary facilities, the pits with relatively minor engineering can be converted to large storage reservoirs.

Iran Wants to Trade Oil For Italian Made Goods

A special trade envoy from Prime Minister Mossadegh in Iran, announced in Rome, Italy, recently that he will sign private industrial contracts to exchange $100.000,000 in Persian crude oil, at half the world price, for Italian manufactured goods.

Dyahanquin Ahy, special envoy, stated that the next question would be whether the Italian government would grant import and export licenses to receive the oil in Rome, and to send Iran the goods.

Oil Income Down in 1952 Chase Bank Report Shows

Chase National Bank's annual oil survey of 30 oil companies, released recently, predicted keener competition in the oil business throughout the world. The booklet, prepared by Frederick G. Couqueron of Chase's petroleum department, is entitled "Financial Analysis of 30 Oil Companies."

The survey reported that greater competition is expected due in a large part to the Federal Government's request to provide 1,000,000 bbl per day of reserve capacity, as well as the normal rise in consumer demands in the U.S.

Most significant development in the study of the world oil picture, the report revealed, is the expansion of crude oil production and construction of new refineries in Western Europe. New facilities more than offset loss of production from Iran.

Crude oil output in all nations outside the Soviet Union totaled 11,200,000 bbl daily, a gain of 61 per cent since the end of World War II.

Total income of the 30 companies was $2,020,000,000 last year, a decrease of 3.3 per cent from 1951. Decline was attributed principally to increased material costs, wages, and taxes, with no significant change in crude oil prices.

Sun Oil Distributes Stock

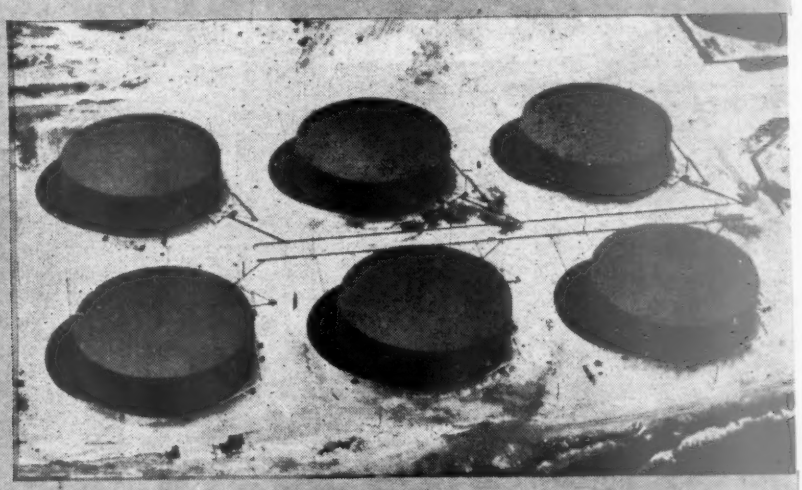
More than $9,250,000 worth of Sun Oil Company common stock is being distributed to 7571 company employees. They participated in a plan for buying stock, with the company contributing one dollar for every two dollars they invested. Now the plan has matured, and certificates for 130,455 shares are being distributed to them.

NEWLY INSTALLED OFFICERS of the Los Angeles Desk and Derrick Club met for dinner at the Petroleum Club to discuss plans for the coming year, recently. They were: Dorothy Clancy, Sudduth and Company, recording secretary; Louise Starkweather, Richfield Oil, second vice president; Minnie Hockett, Bankline Oil, treasurer; Betty Goritz, Western Oil and Gas Association, corresponding secretary, and Jeannette Funston, Monterey Oil, president. Dorothy Munger, Munger Oilogram, is first vice president.

how tanks grow in the caribbean

Six stages in the growth-construction of the largest storage tanks in the Caribbean... 180 feet in diameter, 48 feet high—216,000 bbls. capacity each.

and how they look upon completion



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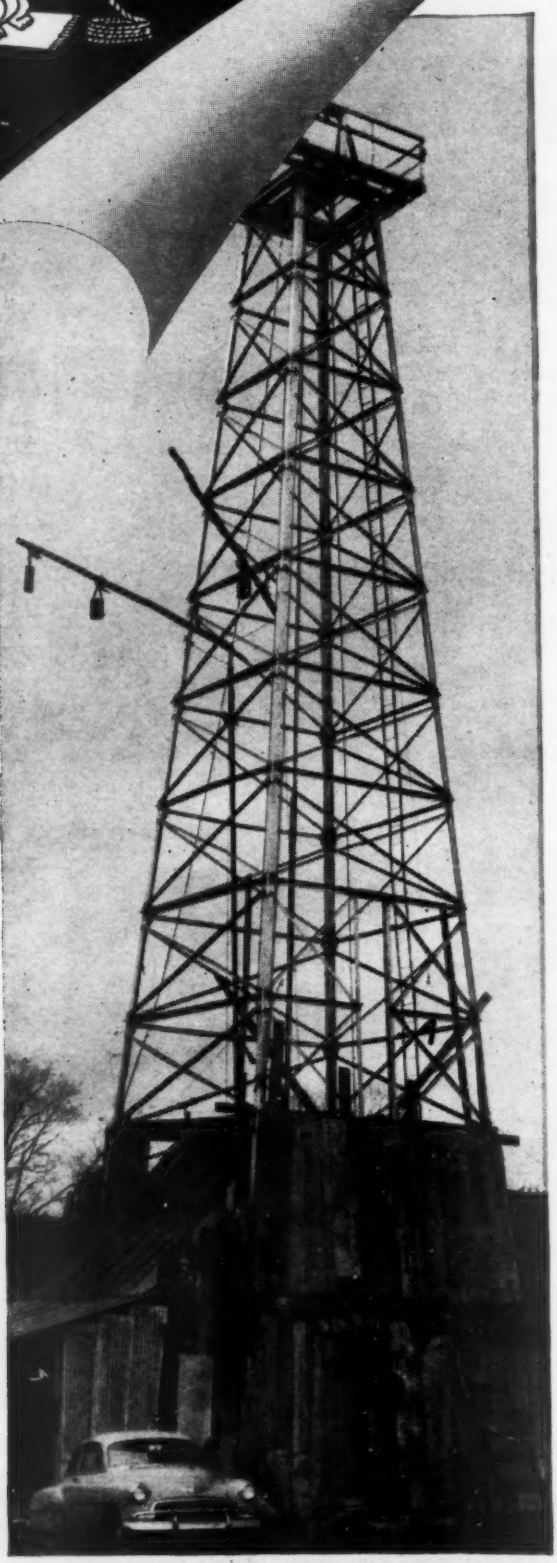
World's deepest with 12,000-ft.

THEY'RE down 11,045 ft. by cable tool and still going. It's the deepest well ever drilled by cable tool; it's New York State Natural Gas Co.'s new well at Van Etten, N. Y.

The drilling rig is equipped with American Tiger Brand tapered drilling and sand lines, both of which are the *longest* tapered lines ever made. American Steel & Wire engineered them especially for this tough job.

Acme Drilling Co. of Greensburg, Pa. started the well for New York State Natural Gas Co. with a competitive line. After reaching a depth requiring a tapered line, a competitive line was used. When that one wore out, the two companies concerned asked for a line with continuous tapered sections that would assure them the longest possible service at reasonable cost. New York State Natural Gas Co., Acme Drilling, and American Steel & Wire personnel got together to discuss the problem. Our engineers went to work and came up with two 12,000-ft. lines that give excellent service



A SPECIAL 12,000-FT. tapered Tiger Brand Drilling Line has taken this cable tool well down to a record-breaking 11,045 ft. American Wire Rope Engineers designed this line specially to meet the tough requirements of this job.

CLAMPING THE DRILLING LINE. Both this line and the sand line, used for bailing, are continuous tapered Tiger Brand Lines. Each one is 12,000-ft. long—the longest tapered lines ever made.

XUM

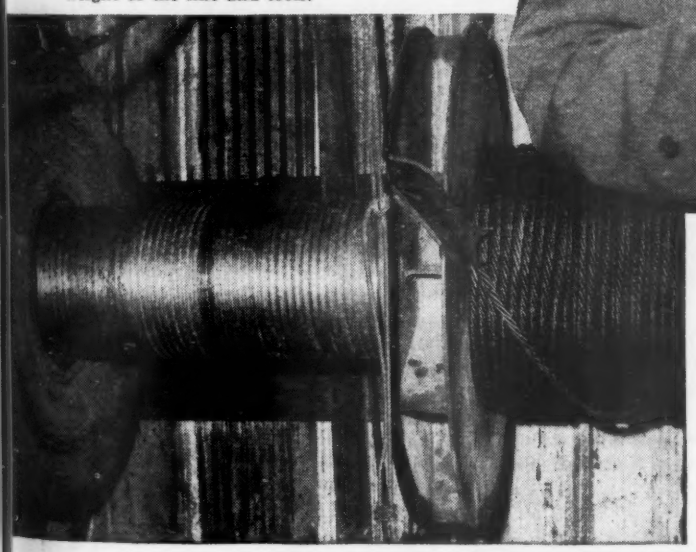
cable tool well drilled Tiger Brand Tapered Wire Line

under the extreme abrasive wear encountered in this deep well. They are performing so well that the New York State Natural Gas Co. has ordered *another* identical Tiger Brand Tapered Drilling Line for use when the present one eventually wears out.

American Wire Rope Engineers can design a suitable wire rope for *any* special job you may have. And when they do the engineering, you can be sure of getting just the right combination of strength, durability and flexibility. Get in touch with the nearest sales office for their help.

MEASURING THE DIAMETER of the drilling line to check for wear. This special Tiger Brand Line is holding up so well that New York State Natural Gas Co. has already ordered another Tiger Brand Line just like it.

THIS IS THE BULL WHEEL WITH the 1" section of drilling line still wound on it. This line tapers from 1" down to ¾" at the tool end. Additional strength and diameter is needed at the top to support the weight of the line and tools.



FOR THE EVERYDAY JOBS, GET THIS HANDY GUIDE BOOK

Most of your tough rope jobs can be handled efficiently with one of the several hundred *standard* Tiger Brand Wire Lines. This "Wire Rope Recommendation Book" tells you which one to use for each job . . . helps you get the *right* rope every time. Just send the coupon.

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U·S·S AMERICAN TIGER BRAND WIRE ROPE

Excellay Preformed

UNITED STATES STEEL

New Spraberry Order Out

A new order has been issued by the Texas Railroad Commission in the Spraberry trend of West Texas, prohibiting production of oil and gas "unless all of the gas incident to the production be made available for legal uses."

The Commission's April order closing the entire field was declared illegal recently. Injunctions obtained in state district court made final its judgment, which permitted production of wells that had connections to gasoline plants or pipe lines.

The Commission stated: "It is the further intent and purpose of this order that as available facilities for diverting casinghead gas to such legal use or uses are increased, the number of shut-down days will be decreased commensurate with the increased facilities until the field is again open to full allowed production.

Standard Film Produced

A monthly newsreel for students in schools and colleges of 11 Midwest states will be sponsored as a public service by Standard Oil Company. Produced by Warner Pathe News under the guidance of an advisory board of educators, the News Magazine of the screen is a dramatic report on world and national events. The films will carry a Standard Oil Company credit line but no advertising.

Middle South Oil Reserves Up 8 Per Cent from 1951

Estimated recoverable reserves of crude oil in proved fields in the Middle South, reported by the American Petroleum Institute as of December 31, 1952, were 3.2 billion barrels — an increase of 8.7 per cent over December 31, 1951, according to the *Middle South News*. The total United States increase for the same period was 1.7 per cent.

Estimated recoverable reserves of natural gas in proved fields in the Middle South, as reported by the American Gas Association, increased 7.4 per cent during 1952 and now amount to over 34,800 billion cubic feet.

A considerable increase in drilling activity in the Middle South during 1952 was reported. There was more wildcatting in the Middle South as compared to 1951, with the number of productive tests up 39 per cent for the period.

In 1952, 3188 new wells were drilled in the Middle South with a total footage of almost 20,000,000 ft. Of these wells 1485 were oil producers, 96 were distillate producers, and 245 produced natural gas.

Estimated number of new wells to be drilled this year is 5.7 per cent above 1952 and the number of new wildcats is estimated at 10.2 per cent above last year.

Middle East Oil Prices Hiked

Price boosts in the Middle East, as much as 25 cents a barrel, have been announced by several major oil companies and suppliers.

Esso Export Corporation, which is owned by Standard Oil Jersey, has announced raising of prices of Persian Gulf crude 25 cents a barrel and East-Mediterranean crude 10 cents a barrel.

Previously Mideast & Crude Sales, Ltd., owned by Standard Oil of California and The Texas Company, has announced hiking of its prices.

First move to increase Middle East oil prices was made by Gulf Oil Company with the announcement that its subsidiary Gulf Exploring Company is increasing its price for Kuwait crude oil by 25 cents a barrel. This was followed by announcement from Anglo-Iranian Oil Company, who posted price increases for Kuwait, Iraq, Persian Gulf, and Eastern Mediterranean crude.

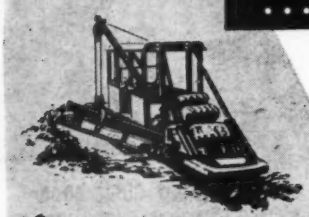
In New York-New England areas prices of home heating oil and kerosine have been lowered. Socony Vacuum Oil and Esso Standard Oil announced price cuts on its No. 2 heating oil, and other distillate fuels.

An investigation guided by Representative John W. Heselton is being made of the price rise in the states. Heselton has introduced a bill to set up an 11-member National Petroleum Commission that apparently would have power to impose rigid price controls, on gasoline, fuel, natural gas, and kindred products. It is expected the Congress will adjourn without making any concrete recommendations.

It takes a FULL team

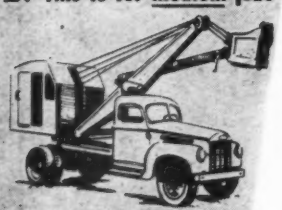
... whether it's a barber shop quartet

... or digging equipment



1. This is for big jobs

2. This is for medium jobs



3. Sherman for all other jobs

On many excavating jobs the use of big equipment is costly and time-consuming. The Sherman Power Digger is designed so that you get all the advantages of power digging on these jobs. Thousands of users have proved that the Sherman Power Digger reduces costs. Write today for descriptive literature S4.

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SHERMAN PRODUCTS, Inc.
Royal Oak, Michigan
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Hubbardston, Mass.

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Patent No. 2,303,825
Other patents pending

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Here is a typical problem. . . . Ingersoll-Rand Air Motors solved this tough control problem in a paper mill. Since steam and acid conditions prevailed, manual operation of digester dump valves was extremely dangerous. These conditions also prevented satisfactory use of electric motors and controls. Size 55SM Air Motors were installed, dumping was controlled from the charging floor 50 feet above the dump valves, and stand-by valve crews were no longer necessary, due to the reliable, trouble-free operation of the Ingersoll-Rand Air Motors.

When wide ranges of operating speeds are desired . . . when instantaneous starting and stopping is needed . . . when the motor will be subjected to frequent stalling and overloads . . . when wet, acid, or explosive atmospheres, or high temperatures make operations too hazardous for direct manual control . . . when expensive and complicated protection devices would otherwise be required . . . when compact motor units are essential . . . and finally, when installation and maintenance costs must be kept low . . . the Ingersoll-Rand Air Motor is the answer to the problem.

Write, wire, or phone your nearest Ingersoll-Rand branch office for help with your tough control and drive problems . . . or request the new Air Motor Bulletin, Form 5072, which gives full information on over 110 sizes of Air Motors . . . both Piston and Multi-Vane types . . . speeds from 5400 to 19 r.p.m. . . . from 1 to 24 H.P. . . . or request information on fractional horsepower Air Motors.

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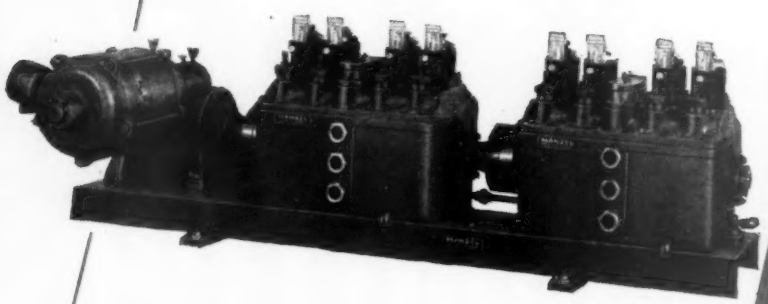
HOW TO CURE

"Fluid-Feedosis"*

A CASE HISTORY

PROBLEM: Chemical Companies needed really dependable equipment for high pressure lubrication of compressor cylinders and bearings.



SOLUTION: Manzel developed a completely new line of heavy duty Force Feed Lubricators that pump S. A. E. 40 oil at pressures up to 30,000 PSIG. Enthusiastic reports of performance are being received from users.

*Difficulties in pumping chemicals, oils, and other fluids in accurate quantities for lubrication, chemical treating, or other purposes.

For the solution to lubrication difficulties, or chemical feeding problems, more and more companies are turning to Manzel. For 50 years a leader in the field, Manzel is today a flexible, fast-moving organization with the special technical skill for meeting *your* needs quickly and economically. Write for further information about Manzel Force Feed Lubricators and Chemical Feeders.

Safeguard high priced machinery with MANZEL FORCE FEED LUBRICATION

- Reduce Wear
- Prevent Breakdown
- Slash oil consumption
- Insure Round-the-Clock Operation

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A DIVISION OF FRONTIER INDUSTRIES, INC.

News

Denying of Appeal Asked In Tax Gathering Case

Texas attorney General John Ben Shepperd in a prepared brief before the United States Supreme Court, asked the court to deny an attempted appeal by Panhandle Eastern Pipe Line Company and Michigan-Wisconsin Pipe Line Company in test cases, or to affirm the state appellate court's opinion that the tax is constitutional.

Approximately $1,000,000 per month is being paid to the state under protest by 117 companies that have sued for refunds. Another $1,000,000 is being paid monthly without protest by El Paso Natural Gas Company.

The state contends pipe lines depend upon state regulation for their existence. This applies to gas used inside Texas as well as out of the state.

Washington to Join IOCC

The state of Washington has made application to join the Interstate Oil Compact Commission, according to Governor Edward F. Arn, Kansas, chairman of IOCC. Application was signed by the governor of Washington, Governor Arthur B. Langlie, and upon acceptance into the compact, Washington will become the fifth associate member of the Compact.

Ten Conoco Awards Granted

Ten 1953 high school graduates from five states have been awarded college scholarships by Continental Oil Company, they were advised this week by President L. F. McCollum.

Winners of the 1953 Conoco Scholarships are Marilyn Aylor, Livingston, Texas; Charlotte Cheatwood, Clinton, Oklahoma; Patricia Clarke, Muskogee, Oklahoma; Joel Gilbert, Tonkawa, Oklahoma; Ivan Koger, Jr., Fairfax, Oklahoma; Roland Pohler, Glenrock, Wyoming; Johnnie Powell, Jr., Ville Platte, Louisiana; Maud Warren, Elida, New Mexico, and Nancy Ann Lovejoy and Robert Hughes of Ponca Ctiy. They are sons and daughters of Continental employes and won their awards in competition with other applicants from 13 states.

Purchase Order Filing On Stainless Steel

Oil and gas operators who want priorities assistance in getting nickel-bearing stainless steel must file purchase orders for the steel with the Petroleum Administration for Defense, Deputy Administrator Joseph A. LaFortune emphasized.

Also, he reminded, no operator may self-certify for any amount of such steel, no matter how small. Only if he can get the steel without priorities assistance may he do so without filing the purchase order.

Nickle-bearing stainless steel will be under allocation only until the end of the third quarter of 1953, September 30. No provision has been made for fourth-quarter allocations.

PERSONALS

J. B. Steele has resigned as vice president, Kewanee Oil Company.

Steele first went to Oklahoma from Illinois in 1915 and after working for a short time as a scout for the old Cosden Oil and Gas Company, joined his father to help him with the Mid-Continent operations of the Enterprise Transit Company and The Kewanee Oil and Gas Company. A few years later he was superintendent of operations.

In 1937 the Enterprise Transit Company and The Kewanee Oil and Gas Company were merged into what is now known as the Kewanee Oil Company. Steele continued to serve as superintendent for this company in charge of all its Mid-Continent operations until 1947 when he was made general superintendent in charge of all operations. In June, 1951 he was elected to the board of directors and a year ago was promoted to vice president, the position he now holds.

Dr. James H. Wiegand, one of the country's recognized authorities on double-base solid propellants for rockets and guided missiles, has been added to the staff of Southwest Research Institute. Dr. Wiegand was named to the post of assistant chairman of the Institute's department of chemistry and chemical engineering, and will play a leading role in the non-profit industrial laboratory's growing program in the fields of high energy materials, including explosives, propellants, pyrotechnics, and incendiaries.

H. L. Phillips

H. B. Smith

J. W. Jordan

H. L. Phillips has been named chairman of the board, of Sinclair Oil and Gas Company. The board also elected **H. B. Smith** president and chief executive officer of the company to succeed Phillips.

Executive offices will be maintained in Tulsa, Oklahoma, under the direction of **H. B. Smith,** president, and **J. W. Jordan,** executive vice president.

Phillips, who has been president of the producing company since 1930, joined Sinclair Oil and Gas Refining Company in its legal department in July, 1916. In 1922, he was made president of Sinclair Crude Oil Purchasing Company, assuming the presidency of Sinclair Oil and Gas Company in October, 1930.

He is a director of Sinclair Oil Corporation, the National Bank of Tulsa, the Great Lakes Pipe Line Company, Platte Pipe Line Company and the American Petroleum Institute.

Smith, who succeeds Phillips as president, joined Sinclair Oil and Gas Company in the land department in 1919. Elected a vice president of the production company in 1922, he was made executive vice president in 1952. Jordan entered the oil business as an employee of Sinclair-Cudahy Pipe Line Company in June, 1916, transferring to the producing company in 1919 on his return from World War I. He was appointed assistant to the chairman in 1938 and in 1940 was made general superintendent. In 1941, he was elected vice president in charge of production, and in 1952, was named executive vice president.

C. H. Dodson, manager of the Chicago sales division of The Texas Company since 1950, has been named assistant to the executive vice president of the Company.

Ben Halsell, manager of the Boston division will succeed Dodson in Chicago.

Dodson, who will be stationed in New York, has been with The Texas Company since 1927. He was graduated from Texas A. and M. College in 1926, and later attended Columbia University.

J. A. Horner

T. P. Simpson

D. D. Bovaird

R. S. Durkee

J. A. Horner has been appointed secretary of Shell Oil Company to succeed **F. W. Woods,** who has retired. Horner formerly was administrative assistant to the president and assistant secretary. He has degrees in law and arts from Oklahoma University at Norman. Horner joined Shell as an attorney at Tulsa in 1936 and served with the company later at Centralia, Illinois, and New York.

Woods joined Shell in 1920 as a chief accountant at Tulsa. He also served at St. Louis and Houston, Texas, before coming to New York in 1934. In 1940, he was appointed secretary.

Thomas P. Simpson has been named assistant director of manufacturing of the General Petroleum Corporation. In his new post, Simpson will report to Gale L. Adams, General's vice president and director of manufacturing.

Simpson joined General Petroleum in 1924 soon after his graduation from the California Institute of Technology. In 1935 he was transferred to the Socony-Vacuum Oil Company, Inc., of which General Petroleum is Western affiliate, as chief development engineer of the Socony-Vacuum laboratories.

Since 1947 Simpson has been director of Socony-Vacuum's research and development laboratories, with headquarters at Paulsboro, New Jersey.

Davis D. Bovaird, president of Bovaird Supply Company, of Tulsa, Oklahoma, has been named president of the Petroleum Equipment Suppliers Association. Election was made at the group's annual meeting in Tulsa, June 30. Newly elected vice president is **Rodney S. Durkee,** president of Lane Wells Company, Los Angeles.

Also elected were 55 directors. **D. S. Faulkner,** National Supply Company, Torrance, California, was named director emeritus of the Pacific district.

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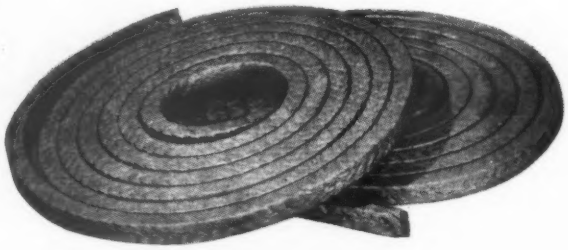
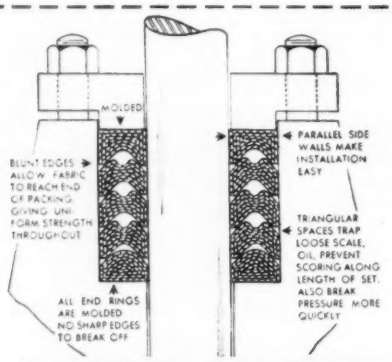
Style 251. Recommended for reciprocating rods handling acid sludge and oils not over 400 degrees F. In coil form this packing makes an excellent filter press gasket. Made with a molded channel composed of layers of high-quality asbestos, frictioned together with a compound highly resistant to liquids encountered in refinery service.



U. S. CENTRIFUGAL PUMP PACKING

Style 193. For centrifugal pumps, or other rotating or oscillating rods or shafts, handling hot or cold, fresh or salt water, oil, brine, weak acids, caustic solutions and ammonia. High-grade asbestos, thoroughly lubricated and graphited, before braiding, by an exclusive "U.S." process.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BLUNT EDGES ALLOW FABRIC TO REACH END OF PACKING, GIVING UNIFORM STRENGTH THROUGHOUT
PARALLEL SIDE WALLS MAKE INSTALLATION EASY
TRIANGULAR SPACES TRAP LOOSE SCALE, OIL, PREVENT SCORING ALONG LENGTH OF SET, ALSO BREAK PRESSURE MORE QUICKLY
ALL END RINGS ARE MOLDED NO SHARP EDGES TO BREAK OFF

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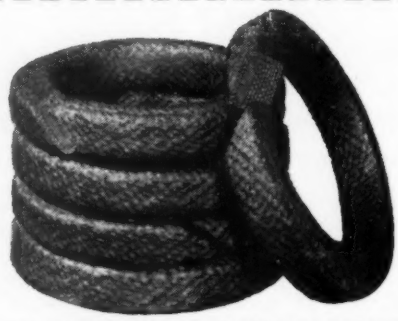
Styles 126, 136. For reciprocating and centrifugal pump rods and valve stems handling light caustic and other corrosive solutions. Made from asbestos yarn, thoroughly treated with a special "U.S." caustic-resisting compound, and graphited. Style 126 is made in round cross-section. Style 136 is square cross-section.



U. S. RAINBESTOS HIGH-PRESSURE ROD AND PLUNGER PACKING

Style 101. For packing reciprocating or oscillating rods and plungers against high-pressure steam, air and gas up to 500 degrees F. Made from selected asbestos cloth, with a genuine U. S. Rainbow non-hardening cushion, formed square, and treated with heat-resisting lubricants and graphite.

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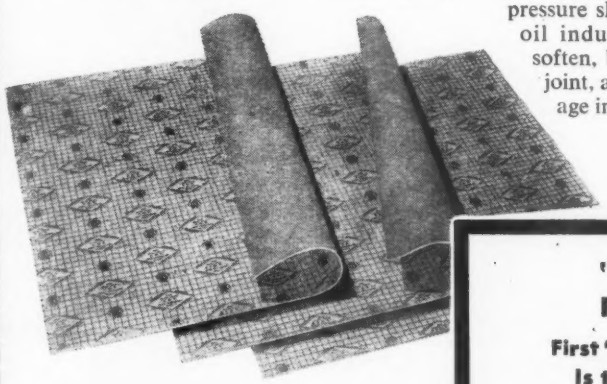

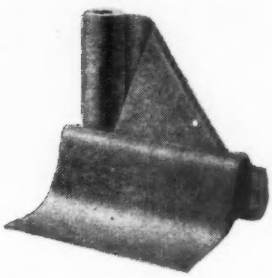

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In several styles, made from high-quality cotton fabric and nylon insertions with Neoprene cover stocks impervious to the action of cold oils and gasoline.

Style P-2901. Supersensitive sheet. 1/32" thick, 36" wide.

Style P-2138. Cotton sheeting insertion, in 36" width only, 1/32" thick and up.

Style P-2133. Medium wt. duck insertion, 46" wide, 1/16" thick and over.

Style P-2904. Nylon insertion in 40" widths, 1/16" thick and over.

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First "U. S." Packing Style Number Listed for Each Condition Is the Best Recommendation for that Particular Service

Service	Brine; Water, Cold	Water, Hot	Oil Distillates	Propane and Butane	Oil Up to 400° F.	Oil Over 400° F.	Ammonia	Caustic	Acid
Centrifugal....	193	193	413	16193	193	512	193	Weak 136 Strong 293	293
Reciprocating Steam End..	101	101	101	101	101	101	101	101	101
Fluid End....	16010	16010	16012 251	16012 251 16133	16022 251	16022 512	133	160 2 251	293
On Piston...	463	453	575	575	...	...	...	...	...
Valve Stem....	125	125	413	16193 16133	125	512	125	125	293
Gaskets.....	9	9	899	899	899	899	9	9	19069 899

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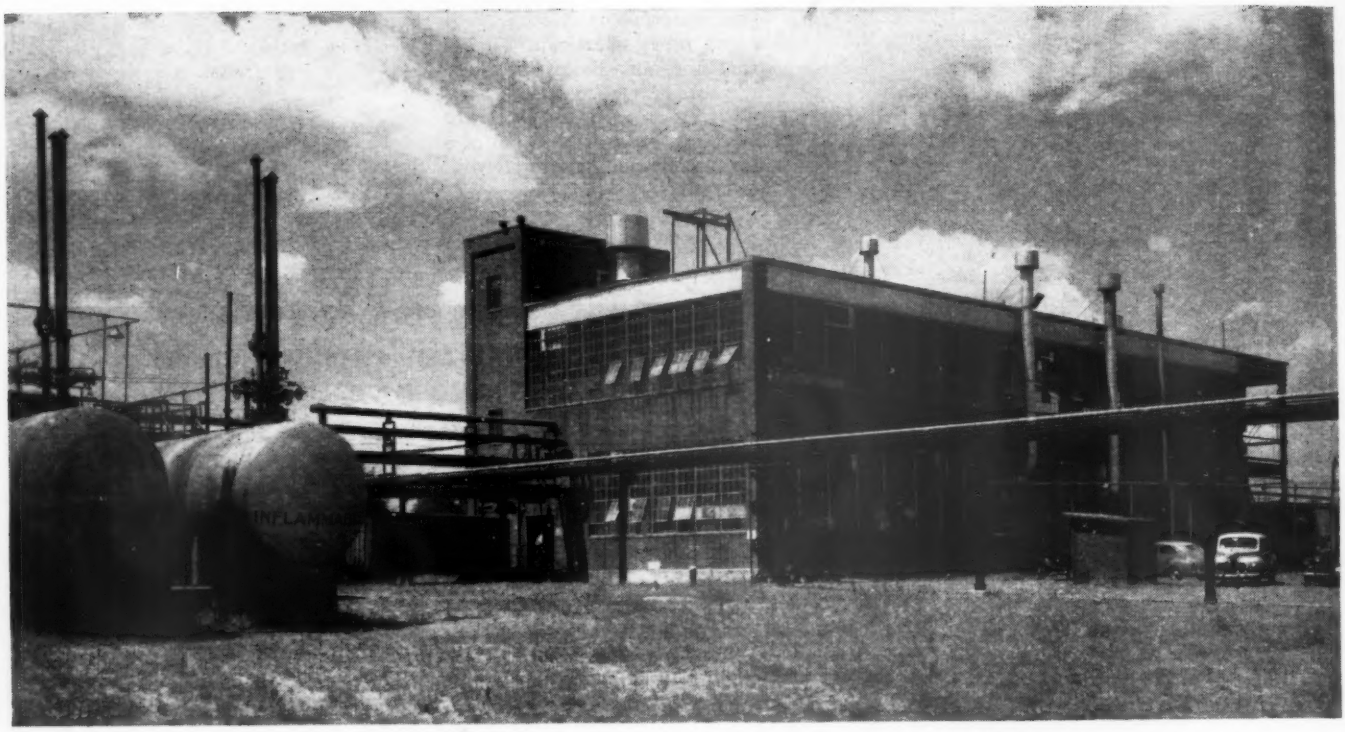

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VALVES | **FORGED & CAST STEEL, IRON & BRONZE, LUBRICATED PLUG VALVES**

DALE NIX (center) receives his Distinguished Achievement Medal from Colorado Mines' Board President Lester C. Thomas. Mines President, Dr. John Vanderwilt, looks on.

▸ **Dale Nix,** vice president in charge of technical and supply services for the Arabian American Oil Company, was recently awarded the Distinguished Achievement Medal by the Colorado School of Mines. The award is equivalent to an honorary degree.

Nix entered the Colorado School of Mines shortly after World War I and was graduated in 1926. His first engineering job in the oil industry was with Marland Oil Company of Texas, and from 1928 until 1933 he was with the California Company in Texas. Nix joined the Bahrain Petroleum Company as assistant resident manager in 1933 and in 1938 Standard Oil of California as petroleum engineer in the foreign department.

In 1940 Nix transferred to Aramco as supervisor of producing operations. He became manager of producing, pipelines, and transportation department in 1948, and two years later, general manager of oil operations. He was appointed to his present position last year.

▸ **Lawrence Cade, Siro Vazquez, Martin E. Jones,** and **Leo E. Lowry,** all residents in Venezuela, have been named directors of Creole Petroleum Corporation. This increases the number of members of the board from 10 to 14. All of the new directors have had long service with the Creole Petroleum Corporation and other affiliated interests of the Standard Oil Company (New Jersey).

Cade went to Venezuela as a driller in 1932 and worked in various districts and divisions of the company, having been manager in both the Eastern and Western divisions. For the past year Cade has been in the Caracas office.

Vazquez joined Standard of Venezuela in 1937. After completing various assignments in the fields, Dr. Vazquez was transferred to Caracas as chief petroleum engineer, later becoming manager of the production department.

Lowry was first employed by Carter Oil upon his graduation from Oklahoma A & M College in 1937. He was recently appointed comptroller of the company with headquarters in Caracas, Venezuela, which position he is now resigning.

Jones began his career with the industry when he was employed by Carter in Wilson, Oklahoma, as a student trainee. In 1938 he was transferred as a lawyer to the Caracas office of Standard Oil of Venezuela. In 1950 he became a member of Creole's management committee.

Announcement was also made of the election of **John E. Andrews** as comptroller of the corporation to succeed Lowry. Andrews began his career with the company in 1937 when he was employed as a junior roustabout and material yardman with the Humble Oil and Refining Company in Houston, Texas.

▸ **Philip C. Humphrey** has joined the staff of the Oil Industry Information Committee of the American Petroleum Institute. His appointment as deputy director was announced by executive director, H. B. Miller.

Humphrey came to the OIIC from The Texas Company, where he had been manager of public relations for the last 11 years.

He has been identified with the Oil Industry Information Committee program since its inception in 1947, and has served three terms as a vice chairman of the national group.

▸ **W. V. Carver** has been named assistant comptroller of Socony-Vacuum Oil Company, Inc. He was formerly general auditor. Other changes in the company's comptroller's department are:

G. E. Bowden, formerly assistant to the comptroller, becomes general auditor.

F. T. Freitag, formerly manager of the audit department, becomes assistant general auditor.

A. O. Iwen, accounting and office manager of the company's West Africa operations, and **R. S. Walters,** accounting and office manager of producing operations, become assistants to the comptroller in addition to their present duties.

▸ **John E. Rouse,** vice president in charge of operations and a member of the board of directors of Stanolind Oil and Gas Company, has retired from the company after completing 40 years of service with various companies in the oil industry.

Rouse's career in the petroleum industry has included important government service with the Petroleum Administration for War and the Navy Department during World War II.

Rouse went to Tulsa in 1945, as manager of the newly-created manufacturing department of Stanolind Oil and Gas Company. He has been vice president in charge of operations since 1948.

Rouse became associated with the petroleum industry in 1913 upon his graduation from Brown University with a degree in mechanical engineering. His first job was firing stills at the Bayonne, New Jersey, plant of Standard Oil Company (New Jersey).

▸ **Dee Davis** was elected a vice president of The California Company at a meeting of the board of directors of that company. The California Company is engaged in the exploration for and production of petroleum and natural gas. In his new capacity, Davis will continue to function as a director and secretary and treasurer, and will continue to head activities of the finance department.

Davis has over 18 years of service with the Standard Oil Company, having joined The California Company in March 1935 as an accounting clerk in the Dallas office.

In 1942, Davis became chief accountant of The California Company in New Orleans; in 1943, assistant secretary and assistant treasurer; and in 1947 was made secretary and treasurer. Davis was elected a director of The California Company in October 1949. He was graduated from the Southeastern Teachers College and attended the University of Texas Graduate School of Business Administration.

▸ **Dean Edward Steidle,** who has retired after 25 years as head of the Mineral Industries' school, Pennsylvania State College, told the Pennsylvania Grade Crude Oil Association at its 30th annual meeting in Hotel William Penn that **Dr. Elburt F. Osborn,** associate dean, professor of geochemistry and head of the department of earth sciences, would succeed him.

Replacing Dr. Osborn will be **Dr. Orville F. Tuttle,** now petrologist in the geophysical laboratory, Washington, D. C.

Dr. John A. Hipple, formerly chief of the atomic physics section, National Bureau of Standards, Washington, has succeeded **Dr. A. W. Gauger** as director of the Mineral Industries Experiment Station, Dean Steidle said.

Joining the staff of the School of Mineral Industries will be **Dr. G. W. Brindley,** physics department, University of Leeds, England, internationally known authority on crystal structures and clays, Dean Steidle said.

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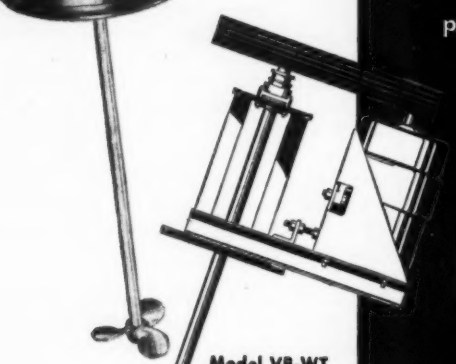

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Personals

H. W. Sanders, vice president, treasurer and member of the executive committee, Union Oil Company of California, resigned as treasurer to assume responsibilities of financial vice president and director of public relations-advertising.

Irving J. Hancock, comptroller, was elected treasurer, and will also remain as comptroller.

Charles F. Parker, resigned as assistant comptroller and was elected assistant treasurer to head new department of economics and financial research.

C. Haines Finnell, director of public relations, was appointed manager of new department of market research and development.

Earl M. Welty, supervisor press-public relations, was appointed assistant to financial vice president Sanders.

Alfred G. Norris was appointed supervisor public relations.

C. F. Wilmsmeier, Western Gulf Oil Company, has been named president of the Petroleum Accountants Society of Los Angeles, for the year which began June 1, 1953. Wilmsmeier has been employed by Western Gulf for 15 years and is presently a member of the general staff in the capacity of fiscal and economic advisor to the vice president. Prior to his appointment to the staff, Wilmsmeier was assistant manager, accounting.

Other officers elected include: First vice president, **V. T. Gilchrist,** The Superior Oil Company; second vice president, **C. A. Peterson,** Shell Oil Company; secretary-treasurer, **R. F. Stine,** Union Oil Company of California.

William F. Brown, petroleum geologist of Mt. Pleasant, Michigan, and **John G. Staudt,** executive vice president of Dowell Inc., of Tulsa, have been appointed to the board of directors of the Brazos Oil and Gas Company. **Calvin A. Campbell** of Midland, Michigan, retired from the board.

The Brazos Oil and Gas Company is a subsidiary of the Dow Chemical Company engaged in petroleum exploration. The president of Brazos Oil and Gas is Dr. A. P. Beutel, Dow vice president and general manager of Dow's Texas division at Freeport.

Brown was graduated from the University of Michigan with a bachelor's degree in geology in 1925 and attended the University of Wisconsin graduate school in 1926.

From 1932, to the present, he has had a consulting business in geology and production of minerals and oil, with operations in Michigan, Indiana, Illinois, Oklahoma, and Texas.

Staudt was graduated from the University of Michigan with a BS degree in chemical engineering in 1931 and took a master's degree at the same school in 1932. He was employed by the Dow Chemical Company in Midland, Michigan, in 1932 to study the use of chemicals in wells to increase oil production. When Dowell was organized the same year, he joined its staff, and was elected to the board of directors in June, 1948.

C. E. Davis, associate deputy administrator for **Defense,** has resigned his position with **PAD,** and has been appointed consultant to PAD. Davis returns to private industry after 23 months of service in the agency. He joined PAD in 1951 as deputy director of the refining division and was named director of the division on September 3, 1951. He was appointed assistant deputy administrator, in charge of domestic petroleum operations on March 1, 1952, and associate deputy administrator on February 16, 1953.

Davis has returned to his position of vice president of Shell Oil in charge of refining.

Harold P. Reynolds, of Chicago, Illinois, has been named as assistant deputy administrator and general counsel of PAD, succeeding **William Simon,** who has resigned to engage in private law practice in Washington, D. C. Simon has served in this position since September 1, 1952.

Reynolds has been engaged in private law practice in Chicago since 1930. He is a graduate of the University of Notre Dame.

Foster J. Schempf, has been named to vice president, exploration, for Stanolind Oil and Gas Company. Other new vice-presidents recently named include: **Frank Lindeman, Jr.,** vice president, production; **V. E. Liles,** vice president administrative, and **George V. Myers,** vice president, financial. All four are members of the company's board of directors.

Schempf, a Stanolind employee since 1933, was graduated from the University of Wisconsin. Lindeman, a graduate of the Colorado School of Mines, has been with the company since 1933. He was former manager of producing.

Dr. William R. Burwell accepted the invitation of the trustees of Stanford University to join the board of directors of Stanford Research Institute. The acceptance was announced by Dr. J. E. Wallace Sterling, president of the university and chairman of the institute's board.

Dr. Burwell is vice chairman of the Clevite Corporation and president of the Brush Electronics Company.

He was board chairman of the Brush Development Company and president and director of Brush Laboratories from 1937 to 1951. His directorships include Associated Industries, Wheeling Steel Corporation, Cleveland-Cliffs Iron Company, and Clevite Corporation.

Joseph A. LaFortune, vice chairman of the board of Warren Petroleum Corporation, has been named deputy administrator of the Petroleum Administration for Defense. He will succeed **J. Ed Warren,** who has completed his tenure as Deputy Administrator.

Warren has been named to the National Petroleum Council, Secretary of the Interior Douglas McKay reported. A two-term president of the Independent Petroleum Association of America before joining PAD, he previously had served both on NPC and on the Military Petroleum Advisory Board. He has rejoined the firm of King, Warren, and Dye, independent petroleum producers, in Midland, Texas.

Excellent opportunity for man with experience in secondary oil recovery by water flooding and who has formal training in microbiology to do sales and service work with firm well established in the field of industrial microorganism control. Training period, salary plus commission. All replies confidential. Write fully Box 152 % The Petroleum Engineer, P. O. Box 1589, Dallas, Texas.

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You can do one of three things:

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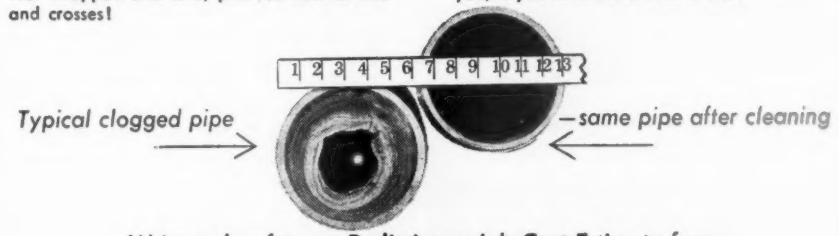

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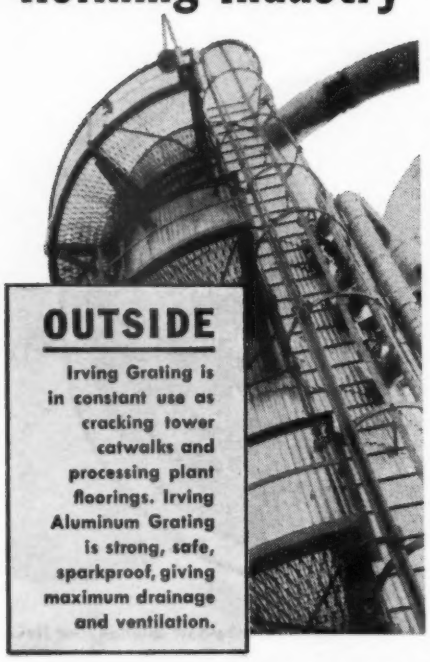
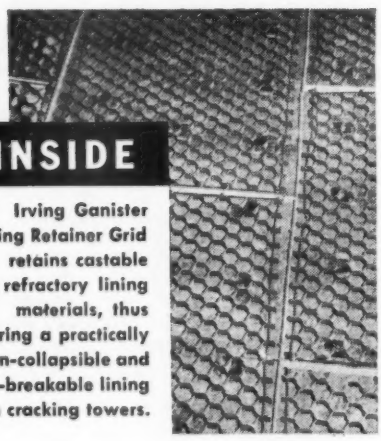


OUTSIDE

Irving Grating is in constant use as cracking tower catwalks and processing plant floorings. Irving Aluminum Grating is strong, safe, sparkproof, giving maximum drainage and ventilation.



INSIDE

Irving Ganister Lining Retainer Grid retains castable refractory lining materials, thus assuring a practically non-collapsible and non-breakable lining in cracking towers.

For Further Information on Irving Gratings, Write

IRVING SUBWAY GRATING CO., INC.
ESTABLISHED 1902

OFFICES and PLANTS at
5052 27th St., Long Island City 1, N. Y.
1852 10th St., Oakland 20, California

DEATHS

Dr. Ferdinand Sonneborn, founder and president of L. Sonneborn Sons, Inc., New York, petroleum refiners and manufacturing chemists, died June 9 after a long illness. Born in Breitenbach, Germany, Dr. Sonneborn came to this country in 1903 and established the company, which is now celebrating its fiftieth anniversary. An authority on pharmaceutical and industrial derivatives of petroleum, Dr. Sonneborn purchased the Daugherty Refinery at Petrolia, Pennsylvania, where he produced petrolatum for use in pharmaceutical and cosmetic preparations and for other industrial applications. During World War I, when embargoes prohibited import of white mineral oil from Europe, Dr. Sonneborn introduced the refining of this product in the United States.

Dr. Sonneborn attended the Universities of Marburg and Munich in Germany and received his PhD degree from the University of Basle, Switzerland.

Sid T. Childress, vice president and general manager of the Rio Bravo Oil Company, a Southern Pacific affiliate, who began his career as a roustabout in the Old Spindletop field near Beaumont, Texas, in 1909, died June 20 at his home.

Childress had a wide and varied career in the oil industry. He worked as a tool dresser, driller, gang pusher, and production foreman for such companies as Gulf, Texas, Rycade, and other companies before joining the Rio Bravo as foreman in 1927. He was vice president and general manager since 1935.

Olney P. Yowell, petroleum pioneer of the West Coast, died at his home in Culpepper, Virginia, on June 19, following an extended illness. Happy, as he was termed by his friends, was toolpusher for Shell Oil Company when the firm drilled its Signal Hill discovery well, Alamitos No. 1, in the Long Beach area in June, 1921. He was a member of Petroleum Production Pioneers.

Sam Houston, vice president of Dunn Brothers, national pipe line company, died recently in Dallas, Texas. Houston had been with the company 14 years, and previously was chief rate clerk of Missouri-Kansas Texas Railroad.

J. A. Patton, independent oil operator, Dallas, Texas, died recently after a short illness. After attending the University of Missouri, Patton moved to Tulsa, Oklahoma, where he was employed by the Central National Bank. He left the bank shortly afterward and entered the oil business.

T. J. Fitch died at his home in Rogers, Arkansas, May 22. Born in Petroleum Center, Pennsylvania, he began working at the age of 17 for the National Transit Pipe Line Company and spent more than 44 years in the pipe line business. He joined Magnolia in December, 1911, and retired April 1, 1938 as vice president, director and manager of pipe lines for Magnolia Pipe Line Company.

Phil Lesh, president of Lesh and McCall, died in a Wichita Falls, Texas, Hospital, May 15. He has pioneered in several Texas oil fields, having come to Texas 40 years ago to help develop the Petrolia field. He drilled the first oil well at Nocona, Texas.

Earl Wagy, who retired as head of Standard of California's economic department in 1946, and Mrs. Wagy, were killed in a car accident May 10. The Wagys collided head on with another automobile that was being driven down the wrong side of the street. Driver of the other car was also killed. Crash occurred in Alameda County, California.

GREAT BEND FISHING TOOL CO.
GREAT BEND, KANSAS
affiliated with

ACME
OIL TOOL COMPANY
• COMPETENT OPERATORS
• ROTARY FISHING TOOL SERVICE
• SPANG CABLE TOOLS • DRILL PIPE
• BLOW OUT PREVENTERS • RENTALS
• COMPLETE OIL FIELD MACHINE SHOP

Acme's New Fishing Tool Shop
WICHITA FALLS, TEXAS
4 miles west of town on the Seymour Road. Phone 3-1910
Tom Seago, Mgr.

RENTALS · MFG · ENG · REPAIRS · ACME

CALL:
OKLAHOMA CITY
MElrose 8-1556
GREAT BEND
7810-7819

TON MILES

5-in. drill pipe — 19.5 lb per foot

25,000 lb EXCESS WEIGHT

DEPTH	0	100	200	300	400	500	600	700	800	900
0	0	2	3	4	5	6	7	8	9	11
1000	12	14	16	17	18	20	21	23	24	26
2000	27	29	31	33	34	36	38	39	41	43
3000	44	47	49	52	54	56	57	60	61	64
4000	65	68	71	74	76	79	81	83	86	88
5000	90	93	96	99	102	106	108	111	113	116
6000	119	122	126	129	132	136	139	142	145	148
7000	150	153	157	161	165	170	173	176	180	182
8000	185	189	193	197	201	206	209	212	216	220
9000	224	228	232	236	241	246	249	253	257	261
10000	265	269	273	277	281	285	290	295	300	305
11000	310	315	320	325	330	335	340	345	350	355
12000	360	364	368	373	378	383	388	393	398	403
13000	408	413	418	423	428	433	439	445	451	457
14000	463	468	473	479	485	491	497	503	509	515
15000	521	527	533	539	546	552	558	564	570	577
16000	583	586	595	602	608	615	621	628	634	641
17000	648	654	661	668	675	681	688	695	702	709
18000	716	723	730	737	744	751	759	766	773	780
19000	788	795	802	810	817	825	832	840	847	855

30,000 lb EXCESS WEIGHT

0	0	2	3	4	5	6	7	8	10	12
1000	14	17	18	20	22	24	25	26	28	30
2000	31	33	36	38	39	41	43	45	47	49
3000	51	54	56	58	60	62	64	67	69	71
4000	74	77	79	82	84	87	90	93	95	97
5000	99	103	106	109	112	116	118	121	124	127
6000	130	135	138	142	145	148	151	154	157	161
7000	163	167	171	174	179	183	187	190	194	198
8000	201	205	209	213	217	222	226	230	234	238
9000	242	246	250	254	259	264	268	272	276	281
10000	286	290	294	298	302	307	312	317	322	327
11000	332	336	340	344	349	354	359	364	369	374
12000	379	384	389	394	399	404	409	415	421	427
13000	433	438	443	448	453	459	465	471	477	483
14000	489	495	501	507	513	519	525	531	537	543
15000	550	556	562	568	575	581	587	594	600	607
16000	613	617	626	633	639	646	653	660	666	673
17000	680	687	694	701	708	715	722	729	736	743
18000	750	757	765	772	779	786	794	801	809	816
19000	824	831	839	846	854	862	869	877	885	893

35,000 lb EXCESS WEIGHT

0	0	2	3	4	5	6	8	10	12	14
1000	16	19	21	22	24	26	27	29	30	32
2000	34	37	39	41	43	45	48	50	52	54
3000	56	58	62	64	66	68	71	73	76	78
4000	80	83	86	89	92	95	98	101	104	106
5000	108	111	114	117	121	125	128	130	134	138
6000	141	146	149	153	156	159	163	166	171	173
7000	176	181	185	190	194	198	203	206	209	213
8000	216	221	226	231	236	241	245	249	253	257
9000	262	266	270	274	279	284	288	292	297	302
10000	307	311	315	319	323	327	332	337	342	347
11000	352	357	362	367	372	377	382	387	392	397
12000	402	407	412	417	422	427	433	439	445	452
13000	457	462	468	474	480	486	492	498	504	510
14000	516	522	528	534	540	546	552	558	564	571
15000	578	585	591	597	604	610	617	623	630	637
16000	643	647	657	664	671	677	684	691	698	705
17000	712	719	726	733	741	748	755	762	770	777
18000	784	792	799	806	814	822	829	837	844	852
19000	860	867	875	883	891	899	906	914	922	930

EXAMPLE: Ton miles per round trip at depth of 12,500 ft with 5-in., 19.5 lb drill pipe and 25,000 lb excess weight = 383.

Courtesy Wickwire Rope, The Colorado Fuel and Iron Corporation

NEW!

LUNKENHEIMER
GLAND-TYPE
BRONZE NEEDLE VALVES

with fine thread-pitch
for precision throttling

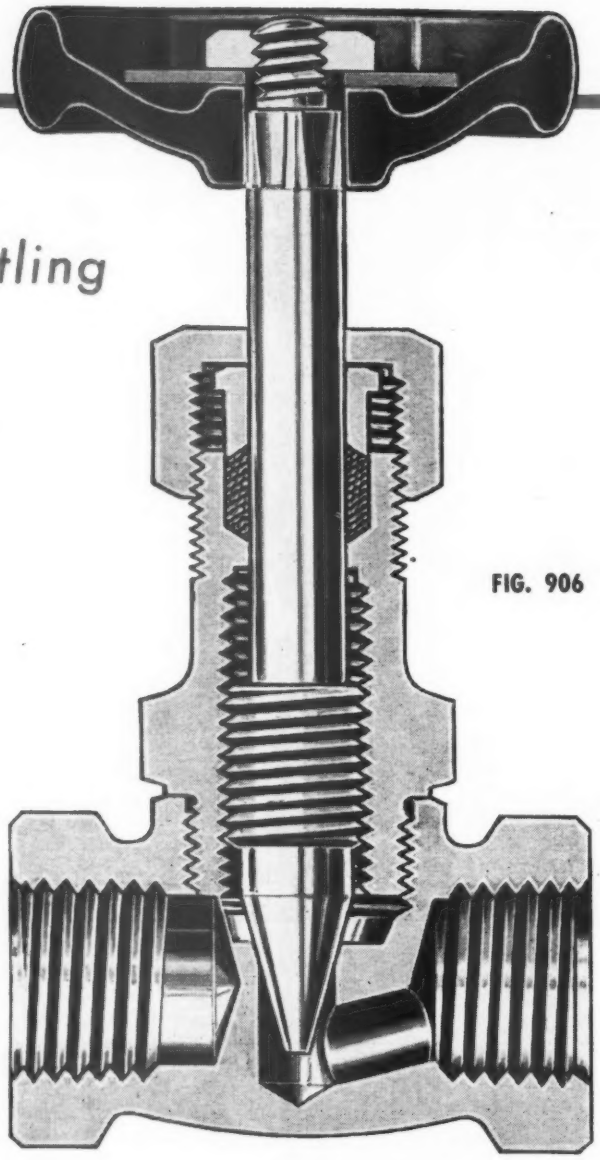


FIG. 906

• WHAT'S NEW ABOUT THEM?

They have a new gland follower . . . they're redesigned from handwheel to seat opening . . . and yet they're competitive in price with non-gland valves.

• HOW ARE THEY FOR INSTRUMENTATION?

Perfect. The handwheels lend themselves to delicate fingertip control. Fig. 1565 has a special indicator handwheel with numbered graduations and a spring lock, if you prefer. They're compact, to fit behind instrument boards, and they have a very fine thread-pitch for close regulation. The seat angle is 30°. They handle 200 lbs. Steam; 400 lbs. W.O.G.

• HOW ABOUT THE STEMS?

Take your choice of "Stemalloy"* or steel in the globe design. "Stemalloy"* is Lunkenheimer's exclusive wear-resisting bronze alloy. Steel stems are cadmium-plated to resist rust.

• WHERE CAN YOU FIND OUT MORE?

Ask for Lunkenheimer's new Needle Valve Bulletin 568. Your distributor has it, or we'll send you a copy. Write The Lunkenheimer Company, Box 360 H, Cincinnati 14, Ohio.

BRONZE • IRON • STEEL

*Patented alloy

LUNKENHEIMER

THE ONE *Great* NAME IN VALVES

L-552-27

TON MILES

5-in. drill pipe — 19.5 lb per foot

40,000 lb EXCESS WEIGHT

DEPTH	0	100	200	300	400	500	600	700	800	900
0	0	2	3	4	6	8	10	12	14	16
1000	18	20	23	25	26	28	30	32	34	36
2000	38	41	43	46	48	50	52	54	56	58
3000	61	64	67	70	72	75	77	80	82	85
4000	89	92	94	97	100	103	106	109	113	116
5000	118	120	124	128	131	135	138	142	144	148
6000	152	156	160	162	167	170	173	177	181	184
7000	188	193	196	198	205	210	214	217	222	225
8000	229	233	237	242	247	252	256	260	264	269
9000	274	278	282	287	292	297	301	305	310	315
10000	320	325	330	335	340	345	350	355	360	365
11000	370	375	380	385	390	395	401	407	413	419
12000	425	430	435	440	446	452	458	464	470	476
13000	482	488	494	500	506	512	518	524	530	536
14000	542	548	554	560	566	572	578	585	592	599
15000	606	613	620	626	633	640	646	653	660	667
16000	674	678	688	695	702	709	716	723	730	737
17000	744	752	759	766	773	781	788	796	803	811
18000	818	826	834	841	849	857	864	872	880	888
19000	896	903	911	919	927	936	944	952	960	968

45,000 lb EXCESS WEIGHT

0	0	2	4	5	7	9	11	13	15	16
1000	18	20	23	25	27	30	32	34	37	39
2000	41	44	46	48	51	54	56	59	61	64
3000	67	70	72	75	78	81	84	87	90	93
4000	96	99	102	105	108	111	115	118	121	125
5000	128	131	135	138	142	145	149	153	156	160
6000	164	167	171	175	179	183	187	190	194	198
7000	202	207	211	215	219	223	228	232	236	240
8000	245	249	254	258	263	267	272	276	281	286
9000	291	295	300	305	310	314	320	324	330	335
10000	339	345	350	355	360	365	371	376	381	387
11000	392	398	403	408	414	419	425	430	438	442
12000	448	453	459	465	471	477	483	489	495	501
13000	507	513	519	525	531	538	544	550	557	563
14000	570	576	582	589	595	602	608	615	622	628
15000	635	642	648	655	662	669	676	683	690	696
16000	704	711	718	726	733	740	747	754	762	769
17000	776	784	791	799	806	814	822	829	837	845
18000	852	860	868	876	884	892	900	907	915	924
19000	932	940	948	956	964	972	981	989	997	1006

50,000 lb EXCESS WEIGHT

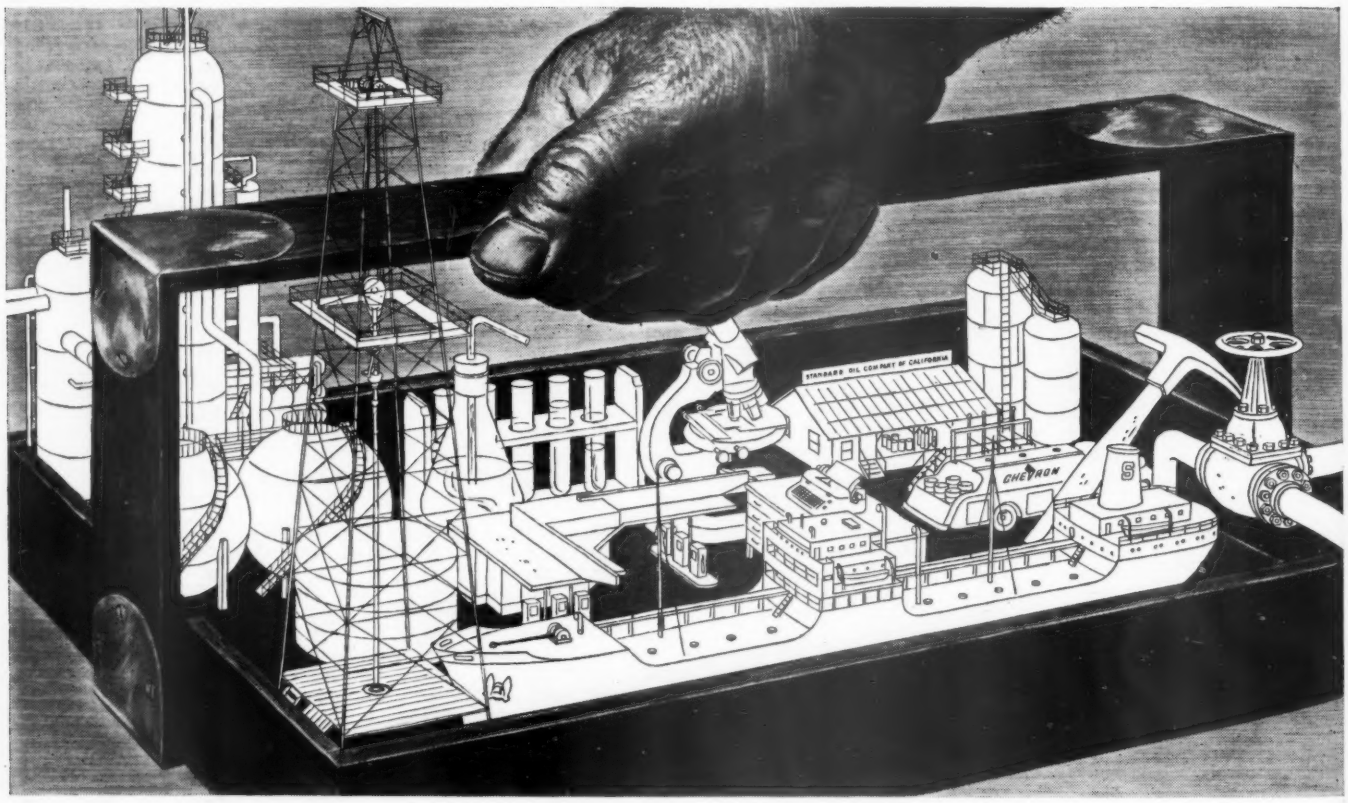
0	0	2	4	6	8	10	12	14	16	18
1000	21	23	25	28	30	32	35	37	40	42
2000	45	48	50	53	55	58	61	64	67	70
3000	73	76	79	81	84	87	90	94	97	100
4000	104	107	110	113	116	120	124	127	131	134
5000	138	141	145	148	152	156	160	163	167	171
6000	175	179	183	187	191	195	199	203	207	212
7000	216	220	224	233	238	238	242	246	251	256
8000	260	265	269	274	279	283	288	293	298	303
9000	308	312	318	322	328	332	338	343	348	353
10000	358	364	369	375	380	385	391	396	402	407
11000	413	418	423	429	435	441	447	453	460	465
12000	470	476	482	488	494	501	507	514	519	525
13000	531	538	544	550	557	563	570	576	583	589
14000	596	602	609	616	622	629	636	643	650	657
15000	663	670	677	684	691	699	706	713	720	727
16000	734	741	749	756	764	771	779	786	794	801
17000	809	816	824	832	839	847	855	863	871	879
18000	886	894	902	910	919	927	935	943	951	959
19000	968	976	984	993	1001	1009	1018	1026	1035	1043

EXAMPLE: Ton miles per round trip at depth of 12,500 ft with 5-in., 19.5 lb drill pipe and 45,000 lb excess weight = 477.

Courtesy Wickwire Rope, The Colorado Fuel and Iron Corporation

How his $51,000 tool kit works for you

Yesterday—*Manpower* and a drill rig contrived from a springy sapling, cable and drill bits sank our first wells. Since the rudimentary tools restricted their depth, they produced little oil. The "tea kettle" refineries of the day were limited, too. They utilized only a portion of the petroleum and turned out a small number of useful products.



Today—*Each of our 34,750 Standard Oilers works with an average $51,000 worth of tools.* They use diesel-electric drill rigs to tap oil pools as far as three or more miles deep. With refinery units that rearrange the structure of petroleum molecules they make each drop of crude useful. Ingenious production, refining and research "tools" like these enable Standard Oilers to make more than 1100 different products from a barrel of oil . . . gasoline 50% better than it was 25 years ago, and wear-saving lubricants; ingredients for wrinkle-resistant fabrics, low-cost plastics and work-saving detergents; sprays to increase farm crops; asphalt for roads, and many more. Standard's investment in "tools" to make oil serve you better amounts to $1,772,000,000. That's $51,000 worth for every Standard Oiler. With this $51,000 tool kit he not only makes more products—he makes them better, cheaper, more easily available. Questions or comments are always welcome. Write: Standard Oil Company of California, P. O. Box 3495-A, San Francisco, California.

STANDARD OIL COMPANY OF CALIFORNIA ***plans ahead to serve you better***

TON MILES

5-in. drill pipe — 19.5 lb per foot

55,000 lb EXCESS WEIGHT

DEPTH	0	100	200	300	400	500	600	700	800	900
0	0	2	4	6	9	11	13	15	18	20
1000	23	25	28	30	33	35	38	40	44	46
2000	49	52	54	57	60	63	66	69	72	75
3000	78	81	84	88	91	94	97	101	104	107
4000	111	114	118	121	125	128	132	136	140	143
5000	147	151	154	158	162	166	170	174	178	182
6000	186	190	195	199	203	207	212	216	220	225
7000	229	234	238	243	247	252	256	261	266	270
8000	275	280	285	290	295	300	304	310	314	320
9000	325	330	335	340	345	350	356	361	367	372
10000	378	383	388	394	400	405	411	416	422	428
11000	434	439	445	451	457	463	469	475	481	487
12000	493	499	506	512	518	524	530	538	544	550
13000	556	563	569	576	582	589	595	602	609	616
14000	622	629	636	643	650	657	665	671	678	685
15000	692	699	706	713	721	728	735	743	750	757
16000	765	772	780	787	793	802	810	818	824	833
17000	841	849	857	864	872	880	888	896	904	912
18000	921	929	937	945	953	962	970	978	987	996
19000	1004	1012	1021	1029	1038	1046	1055	1064	1072	1081

60,000 lb EXCESS WEIGHT

0	0	2	5	7	9	12	14	17	19	22
1000	25	27	30	33	35	38	41	44	47	50
2000	53	56	58	62	65	68	71	74	77	81
3000	84	87	91	94	97	101	104	108	111	115
4000	118	122	126	130	133	137	141	145	149	152
5000	156	160	164	168	172	177	181	185	189	193
6000	198	202	207	211	215	220	224	229	233	238
7000	242	247	252	256	261	266	271	276	281	285
8000	290	295	300	305	310	316	321	326	331	336
9000	342	347	352	358	363	368	374	380	385	391
10000	396	402	408	414	419	425	431	438	443	449
11000	454	464	466	473	479	485	491	497	505	510
12000	516	522	529	535	542	548	554	562	571	576
13000	581	587	594	601	608	614	621	628	636	642
14000	649	656	663	670	676	684	691	698	706	713
15000	720	728	735	742	750	757	765	772	780	787
16000	795	803	810	818	826	834	842	850	857	865
17000	873	881	889	897	905	914	922	930	938	946
18000	955	963	972	980	988	997	1005	1014	1022	1031
19000	1040	1048	1057	1066	1074	1083	1092	1101	1110	1119

EXAMPLE: Ton miles per round trip at depth of 12,500 ft with 5-in., 19.5 lb drill pipe and 55,000 lb excess weight = 524.

TON MILES

5½-in. drill pipe — 24.7 lb per foot

15,000 lb EXCESS WEIGHT

0	0	1	1	2	3	3	4	5	6	7
1000	8	9	10	11	12	14	15	16	17	19
2000	20	22	23	25	26	28	30	31	33	35
3000	37	39	41	43	45	47	49	51	53	55
4000	58	60	62	65	67	70	72	75	77	80
5000	83	86	88	91	94	97	100	103	106	109
6000	112	115	119	122	125	129	132	135	139	142
7000	146	149	153	157	161	164	168	172	176	180
8000	184	188	192	196	200	205	209	213	217	222
9000	226	231	235	240	244	249	254	258	263	268
10000	273	278	282	287	292	297	303	308	313	318
11000	323	329	334	340	345	350	356	362	367	373
12000	379	384	390	396	402	408	414	420	426	432
13000	438	444	450	457	463	469	476	482	488	495
14000	501	508	515	521	528	535	542	549	556	562
15000	569	576	584	591	598	605	612	620	627	634
16000	642	649	657	664	672	679	687	695	702	710
17000	718	726	734	742	750	758	766	774	782	791
18000	799	807	815	824	832	841	849	858	866	875
19000	884	893	901	910	919	928	937	946	955	964

EXAMPLE: Ton miles per round trip at depth of 12,500 ft with 5½-in., 24.7 lb drill pipe and 15,000 lb excess weight = 408.

Courtesy Wickwire Rope, The Colorado Fuel and Iron Corporation

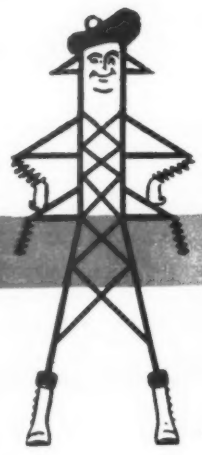
Our Silver Anniversary

Climaxing 25 Successful Years of Partnership with You

Yes . . . we are celebrating the Silver Anniversary of our partnership with you of the petroleum industry. To our way of thinking, it has been a valuable twenty-five years for you as well as us . . . and we are proud to have been able to bring LOW-COST ELECTRICAL POWER to so many organizations in all phases of the petroleum industry. Oil men everywhere are invited to attend our Silver Anniversary meeting at Hotel Muehlebach in Kansas City, Mo., October 5, 6 and 7. Come and bring your power problems with you . . . because this is a meeting not for appraisal of past accomplishments but for planning more and better ways of providing the petroleum industry with EFFICIENT LOW-COST ELECTRICAL POWER. See you in Kansas City.

Welcome

- OIL MEN
- EQUIPMENT MANUFACTURERS
- ALLIED SUPPLIERS
- OIL JOURNALS and PRESS



Petroleum Electric Power Association

ORGANIZED IN 1928 IN THE INTEREST OF
GREATER SERVICE TO THE PETROLEUM INDUSTRY

RELATIVE DISCHARGING CAPACITIES OF PIPES

TABLE 1—RELATIVE DISCHARGING CAPACITIES OF STANDARD PIPE

Pipe size in	Internal diameter d, in	$d^{5/2}$	Pipe size																
			⅛	¼	⅜	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12
⅛	0.269	0.037530	1.0																	
¼	0.364	0.079938	2.1	1.0																
⅜	0.493	0.17065	4.5	2.1	1.0															
½	0.622	0.30512	8.1	3.8	1.8	1.0														
¾	0.824	0.61634	16	7.7	3.6	2.0	1.0													
1	1.049	1.1270	30	14	6.6	3.7	1.8	1.0												
1¼	1.380	2.2372	60	28	13	7.3	3.6	2.0	1.0											
1½	1.610	3.2890	88	41	19	11	5.3	2.9	1.5	1.0										
2	2.067	6.1426	164	77	36	20	10	5.5	2.7	1.9	1.0									
2½	2.469	9.5786	255	120	55	31	16	8.5	4.3	2.9	1.6	1.0								
3	3.068	16.487	439	206	97	54	27	15	7.4	5.0	2.7	1.7	1.0							
3½	3.548	23.711	632	297	139	78	38	21	11	7.2	3.9	2.5	1.4	1.0						
4	4.026	32.523	867	407	191	107	53	29	15	9.9	5.3	3.4	2.0	1.4	1.0					
5	5.047	57.225	1525	716	335	188	93	51	26	17	9.3	6.0	3.5	2.4	1.8	1.0				
6	6.065	90 589	2414	1133	531	297	147	80	40	28	15	9.5	5.5	3.8	2.8	1.6	1.0			
8	7.981	179.95	4795	2251	1054	590	292	160	80	55	29*	19	11	7.6	5.5	3.1	2.0	1.0		
10	10.020	317.81	8468	3976	1862	1042	516	282	142	97	52	33	19	13	9.8	5.6	3.5	1.8	1.0	
12	12.000	498.83	13292	6240	2923	1635	809	443	223	152	81	52	30	21	15	8.7	5.5	2 8	1.6	1.0

The figure opposite the intersection of any two sizes is the number of smaller size pipes required to equal one of the larger.
*Example: How many 2-in. pipes will it take to equal the discharge of one 8-in. pipe? Answer: 29 2-in. pipes.

TABLE 2—RELATIVE DISCHARGING CAPACITIES OF EXTRA STRONG PIPE

Pipe size in	Internal diameter d, in.	$d^{5/2}$	Pipe size																
			⅛	¼	⅜	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12
⅛	0 215	0.021434	1.0																	
¼	0 302	0.050121	2.3	1.0																
⅜	0 423	0.11637	5.4	2.3	1.0															
½	0.546	0.22028	10	4.4	1.9	1.0														
¾	0.742	0.47425	22	9.5	4.1	2.2	1.0													
1	0.957	0.89594	42	18	7 7	4.1	1.9	1.0												
1¼	1.278	1.846	86	37	16	8.4	3.9	2.1	1.0											
1½	1.500	2.7557	129	55	24	13	5.8	3.1	1.5	1.0										
2	1.939	5 2353	244	104	45	24	11	5.8	2.8	1.9	1 0									
2½	2.323	8.224	384	164	71	37	17	9.2	4.5	3.0	1.6	1.0								
3	2.900	14.322	668	286	123	65	30	16	7.8	5.2	2.7	1.7	1.0							
3½	3.364	20.756	968	414	178	94	44	23	11	7.5	4.0	2.5	1.4	1.0						
4	3.826	28.633	1336	571	246	130	60	32	16	10	5.5	3.5	2.0	1.4	1.0					
5	4.813	50.821	2371	1014	437	231	107	57	28	18	9.7	6.2	3.5	2.4	1.8	1.0				
6	5.761	79.661	3717	1589	685	362	168	89	43	29	15	9.7	5.6	3.8	2.8	1.6	1.0			
8	7.625	160.55	7490	3203	1380	729	339	179	87	58	31*	20	11	7.7	5.6	3.2	2.0	1.0		
10	9.750	296.83	13849	5922	2551	1348	626	331	161	108	57	36	21	14	10	5.8	3.7	1.8	1.0	
12	11.750	473.25	22079	9442	4067	2148	998	528	256	172	90	58	33	23	17	9.2	5.9	2.9	1.6	1.0

The figure opposite the intersection of any two sizes is the number of smaller size pipes required to equal one of the larger.
*Example: How many 2-in. extra strong pipes will it take to equal the discharge of one 8-in. extra strong pipe? Answer: 31 2-in. pipes.

Explanation: It is frequently desired to know how many pipes of a certain size are equal in discharging capacity to one pipe of a larger size. Under the same head, the velocity is less in the smaller pipe and the discharge varies as the square root of the fifth power of the inside diameter. Expressed as a formula, the

$$\text{Relative discharging capacity} = \frac{\sqrt{d_L^5}}{\sqrt{d_s^5}} = \frac{d_L^{5/2}}{d_s^{5/2}}$$

where d_L = Actual inside diameter of the larger pipe.
d_s = Actual inside diameter of the smaller pipe.

The accompanying tables covering standard, extra strong, and large diameter pipe were calculated by this formula. It is possible by the use of these tables to find directly the number of small pipes which will (under the same head) give the same discharge as one larger pipe, provided the sizes of pipes in question appear in the same table. An example using more than one table follows:

Example: What size of pipe will be required to equal the discharge of the following?

Four 4-in. standard pipes	$=4\times d^{5/2}=4\times 32.523=$ 130.092
Two 6-in. standard pipes	$=2\times d^{5/2}=2\times 90.589=$ 181.178
Three 8-in. standard pipes	$=3\times d^{5/2}=3\times 179.95=$ 539.85
Two 14-in. O.D. × $\frac{7}{16}$-in. wall	$=2\times d^{5/2}=2\times 624.09=1248.18$
One 18-in. O.D. × ½-in. wall	$=$ $d^{5/2}=$ 1191.6 $=1191.6$
Total—	3290.9

The nearest figure to 3290.9 is found in table 8 on sheet 2 in the column of factors $d^{5/2}$ corresponding to a pipe about 25½ in. I.D. The $d^{2.5}$ factors on tables P 622.001 (sheets 1, 2, 3, 4, and 5) that were published in *The Petroleum Engineer* in June and July, 1942, may be used in place of the $d^{5/2}$ factors in problems such as the one above.

Table from Bulletin No. 21 by courtesy of National Tube Company.

Higher heat transfer efficiency year...after year...after year!

Trane fin and tube are "joined forever"

There is just no substitute for the *mechanically bonded* fin and tube when it comes to producing year-in, year-out efficiency in dry-type fluid cooling.

This fin and tube construction, developed and pioneered by TRANE, provides an extra heat transfer contact that lasts the life of the unit. No solder is used. Result: TRANE Dry-Type Fluid Coolers perform more efficiently year after service-free year.

Flat plate fin construction in these TRANE units gives other advantages. It offers less resistance to air flow and thus reduces fan horsepower required. It stays clean much longer than other types of fin surface. Any dirt or lint collected will be on the leading edge of the fin where it can be brushed off easily.

A variety of special corrosion-resistant metals can be used to meet your requirements exactly. And, for a wide range of applications, you'll find a complete line of TRANE Dry-Type Fluid Coolers in over 22 stock models and sizes, both vertical and horizontal.

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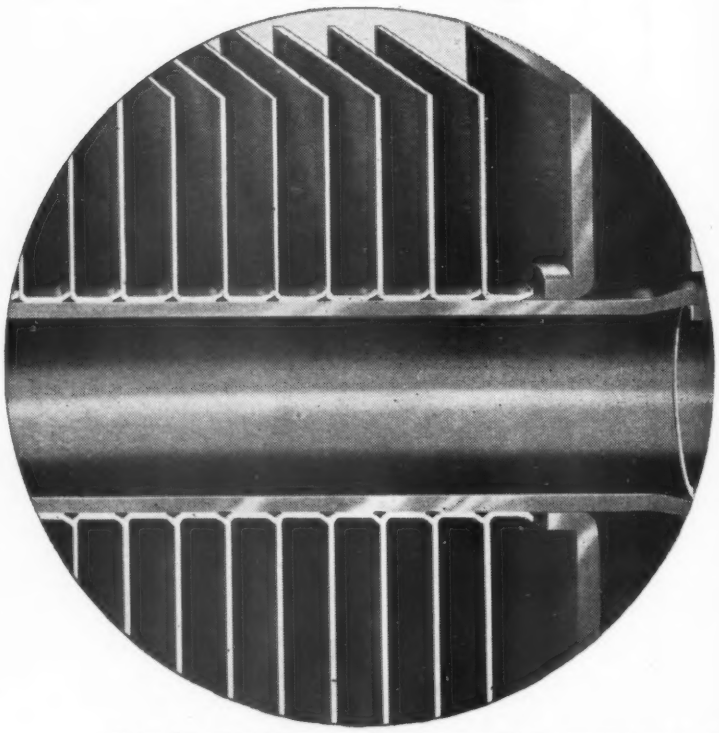
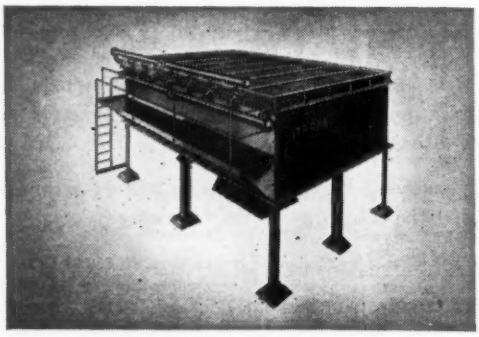
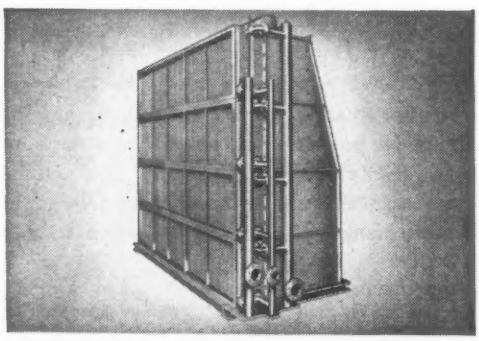


These fins cannot loosen . . . despite a million expansions and contractions. They're *mechanically* bonded. The tube is expanded against the fin collars with tremendous internal pressure. This results in a union as strong and permanent as the metal itself. This strength, plus the extra heat transfer efficiency gained with the metal-to-metal contact gives TRANE Fluid Coolers a longer life and higher efficiency year after year.



TRANE GC Fluid Cooler, fan diameters from 6′ to 16′.



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XUM

RELATIVE DISCHARGING CAPACITIES OF PIPES

TABLE 3—DISCHARGING CAPACITY FACTORS FOR LARGE DIAMETER PIPES

Outside diameter, in.	Thickness, in.	Inside diameter d, in.	$d^{5/2}$	Outside diameter, in.	Thickness, in.	Inside diameter d, in.	$d^{5/2}$	Outside diameter, in.	Thickness, in.	Inside diameter d, in.	$d^{5/2}$	Outside diameter in.	Thickness, in.	Inside diameter d, in.	$d^{5/2}$
14	¼	13.500	669.63		⅜	24.875	3086.1		1 1/16	35.750	7641.7		1/16	59.125	26880
	5/16	13.438	661.91		7/16	24.750	3047.5		1¼	35.500	7508.8		1/32	59.000	26738
	⅜	13.375	654.24		½	24.500	2971.1						1/16	58.875	26597
	11/32	13.313	646.62		⅝	24.250	2895.9	40	¼	39.500	9806.0		3/32	58.750	26456
	⅜	13.250	639.06	1		24.000	2821.8		5/16	39.438	9767.3		⅛	58.500	26175
	13/32	13.125	624.09	1 1/8		23.750	2748.9		⅜	39.375	9728.6		5/32	58.250	25896
	½	13.000	609.34	1¼		23.500	2677.1		11/32	39.313	9690.1	1		58.000	25619
	9/16	12.875	594.80	28	¼	27.625	4011.0		7/16	39.250	9651.6	1 1/8		57.750	25344
	5/8	12.750	580.46		5/16	27.563	3988.4		15/32	39.125	9574.9	1¼		57.500	25071
	¾	12.500	552.43		⅜	27.500	3965.8		½	39.000	9498.6	60	¼	65.500	34722
	7/8	12.250	525.22		7/16	27.438	3943.3		17/32	38.875	9422.7		5/16	65.438	34640
	1	12.000	498.83		½	27.375	3920.9		9/16	38.750	9347.2		11/32	65.375	34556
	1 1/8	11.750	473.25		9/16	27.313	3898.6		19/32	38.500	9197.1		13/32	65.313	34475
16	¼	15.500	945.87		5/8	27.250	3876.3		¾	38.250	9048.5		⅜	65.250	34392
	5/16	15.438	936.36		11/16	27.125	3832.0	1		38.000	8901.4		7/16	65.125	34227
	⅜	15.375	926.91		¾	27.000	3788.0	1 1/8		37.750	8755.7		½	65.000	34063
	11/32	15.313	917.52		13/16	26.875	3744.3	1¼		37.500	8611.5		9/16	64.875	33900
	⅝	15.250	908.19		⅞	26.750	3700.9	42	¼	41.500	11095		⅝	64.750	33736
	13/32	15.125	889.69		15/16	26.500	3615.1		5/16	41.438	11053		¾	64.500	33412
	½	15.000	871.42		1	26.250	3530.4		⅜	41.375	11011		⅞	64.250	33089
	9/16	14.875	853.38	1		26.000	3446.9		11/32	41.313	10970	1		64.000	32768
	⅝	14.750	835.56	1 1/8		25.750	3364.7		⅞	41.250	10928	1 1/8		63.750	32449
	¾	14.500	800 61	1¼		25.500	3283.6		7/16	41.125	10846	1¼		63.500	32132
	⅞	14.250	766.54	30	¼	29.625	4776.9		½	41.000	10764	72	¼	71.500	43228
1		14.000	733.36		5/16	29.563	4751.7		9/16	40.875	10682		5/16	71.438	43135
1 1/8		13.750	701.06		⅜	29.500	4726.7		⅝	40.750	10600		11/32	71.375	43039
18	¼	17.500	1281.1		7/16	29.438	4701.7		¾	40.500	10438		13/32	71.313	42946
	5/16	17.438	1269.7		½	29.375	4676.8		⅞	40.250	10278		⅜	71.250	42851
	⅜	17.375	1258.4		17/32	29.313	4651.9	1		40.000	10119		15/32	71.125	42663
	11/32	17.313	1247.1		⅝	29.250	4627.2	1 1/8		39.750	9061.9		½	71.000	42476
	⅜	17.250	1235.9		19/32	29.125	4577.9	1¼		39.500	9806.0		9/16	70.875	42290
	13/32	17.125	1213.6		½	29.000	4528.9	44	¼	43.500	12480		⅝	70.750	42103
	½	17.000	1191.6		5/16	28.875	4480.3		5/16	43.438	12435		¾	70.500	41732
	9/16	16.875	1169.8		⅝	28.750	4431.9		⅜	43.375	12391		⅞	70 250	41363
	⅝	16.750	1148.3		¾	28.500	4336.2		11/32	43.313	12346	1		70.000	40996
	¾	16.500	1105.9		⅞	28.250	4241.8		⅞	43.250	12302	1 1/8		69.750	40631
	⅞	16.250	1064.5	1		28.000	4148.5		7/16	43.125	12213	1¼		69.500	40268
1		16.000	1024.0	1 1/8		27.750	4056.6		½	43.000	12125	78	¼	77.500	52875
1 1/8		15.750	984.47	1¼		27.500	3965.8		9/16	42.875	12037		5/16	77.438	52770
20	¼	19.500	1679.1	32	¼	31.500	5569.0		⅝	42.750	11949		⅜	77 375	52663
	5/16	19.438	1665.7		5/16	31.438	5541.4		¾	42.500	11775		11/32	77.313	52557
	⅜	19.375	1652.4		⅜	31.375	5513.9		⅞	42.250	11603		⅝	77.250	52450
	11/32	19.313	1639.1		11/32	31.313	5486.5	1		42.000	11432		15/16	77.125	52238
	⅜	19.250	1625.8		⅝	31.250	5459.2	1 1/8		41.750	11263		½	77.000	52027
	13/32	19.125	1599.6		13/16	31.125	5404.7	1¼		41.500	11098		9/16	76 875	51816
	½	19.000	1572.6		½	31.000	5350.6	46	¼	45.500	13965		⅝	76.750	51606
	9/16	18.875	1547.8		29/32	30.875	5296.8		5/16	45.438	13917		¾	76.500	51186
	⅝	18.750	1522.3		⅝	30.750	5243.4		⅜	45.375	13869		⅞	76.250	50769
	¾	18.500	1472.1		¾	30.500	5137.5		11/32	45.313	13821	1		76.000	50354
	⅞	18.250	1422.8		⅞	30.250	5032.8		⅞	45.250	13774	1 1/8		75.750	49941
1		18.000	1374.6	1		30.000	4929.5		7/16	45.125	13679	1¼		75.500	49530
1 1/8		17.750	1327.4	1 1/8		29.750	4827.4		½	45.000	13584	84	¼	83.500	63711
22	¼	21.625	2174.7	1¼		29.500	4726.7		9/16	44.875	13490		5/16	83.438	63593
	5/16	21.563	2159.0	34	¼	33 500	6495.5		5/8	44.750	13396		3/8	83.375	63473
	⅜	21.500	2143.4		5/16	33.438	6465.2		¾	44.500	13210		11/32	83.313	63355
	11/32	21.438	2127.8		⅜	33.375	6435.1		⅞	44 250	13025		⅝	83.250	63236
	⅜	21.375	2112.3		11/32	33.313	6405.0	1		44.000	12842		15/16	83.125	62998
	13/32	21.313	2096.9		⅝	33.250	6375.0	1 1/8		43.750	12660		½	83.000	62762
	⅝	21.250	2081.6		13/16	33.125	6315.2	1¼		43.500	12480		9/16	82.875	62526
	15/16	21.125	2051.1		½	33.000	6255.8	48	¼	47.500	15550		⅝	82.750	62290
	½	21.000	2020.9		27/32	32.875	6196.8		5/16	47.438	15499		¾	82.500	61821
	9/16	20.875	1991.0		⅞	32.750	6138.0		⅜	47.375	15448		⅞	82.250	61354
	⅝	20.750	1961.3		¾	32 500	6021.6		11/32	47.313	15397	1		82 000	60888
	¾	20.500	1902.8		⅞	32.250	5906.4		⅞	47 250	15346	1 1/8		81 750	60425
	⅞	20.250	1845.3	1		32.000	5792.6		7/16	47.125	15245	1¼		81.500	59965
1		20.000	1788.9	1 1/8		31.750	5680.1		½	47.000	15144	90	¼	89.500	75780
1 1/8		19.750	1733.5	1¼		31.500	5569.0		9/16	46.875	15044		5/16	89.438	75649
1¼		19.500	1679.1	36	¼	35.500	7508.8		5/8	46.750	14944		11/32	89.375	75516
24	¼	23.625	2712.9		5/16	35.438	7475.8		¾	46.500	14745		13/32	89.313	75385
	5/16	23.563	2695.0		⅜	35.375	7442.9		⅞	46.250	14547		⅜	89.250	75253
	⅜	23.500	2677.1		11/32	35.313	7410.1	1		46.000	14351		15/32	89.125	74989
	13/32	23.438	2659.4		⅝	35.250	7377.3	1 1/8		45.750	14157		½	89.000	74727
	½	23.375	2641.7		13/16	35.125	7312.1	1¼		45.500	13965		9/16	88 875	74464
	9/16	23.313	2624.1		½	35.000	7247.2	54	¼	53.500	20936		⅝	88.750	74203
	⅝	23.250	2606.5		11/16	34.875	7182.7		5/16	53.438	20875		¾	88.500	73681
	15/16	23.125	2571.6		⅝	34.750	7118.5		⅜	53.375	20813		⅞	88.250	73162
	½	23.000	2537.0		¾	34.500	6991.1		11/32	53.313	20753	1		88.000	72645
	9/16	22.875	2502.7		⅞	34.250	6865.2		⅝	53.250	20692	1 1/8		87.750	72130
	⅝	22.750	2468.6	1		34.000	6740.6		13/16	53.125	20571	1¼		87 500	71618
	¾	22.500	2401.4	1 1/8		33.750	6617.4		½	53.000	20450	96	¼	95.500	89127
	⅞	22.250	2335.2	1¼		33.500	6495.5		9/16	52.875	20329		5/16	95.438	88982
1		22.000	2270.2	38	¼	37.500	8611.5		⅝	52.750	20210		⅜	95.375	88835
1 1/8		21.750	2206.2		5/16	37.438	8575.6		¾	52.500	19971		11/32	95.313	88691
1¼		21.500	2143.4		⅜	37.375	8539.9		⅞	52.250	19734		⅝	95.250	88545
26	¼	25.625	3324.0		11/32	37.313	8504.2	1		52.000	19499		15/16	95.125	88254
	5/16	25.563	3303.8		⅝	37.250	8468.7	1 1/8		51.750	19265		½	95.000	87965
	⅜	25.500	3283.6		13/16	37.125	8397.8	1¼		51.500	19033		9/16	94.875	87676
	13/32	25.438	3263.5		½	37.000	8327.3						⅝	94.750	87387
	½	25.375	3243.5		17/32	36.875	8257.1	60	¼	59.500	27308		¾	94.500	86813
	9/16	25.313	3223.6		⅝	36.750	8187.3		5/16	59.438	27237		⅞	94.250	86239
	⅝	25.250	3203.7		¾	36.500	8048.8		⅜	59.375	27165	1		94.000	85668
	¾	25.125	3164.2		⅞	36.250	7911.7		11/32	59.313	27094	1 1/8		93.750	85100
	⅞	25.000	3125.0	1		36.000	7776.0		⅞	59.250	2702:	1¼		93.500	84534

See Sheet 1 for explanation and example of use.

Table from Bulletin No. 21 by courtesy of National Tube Company.

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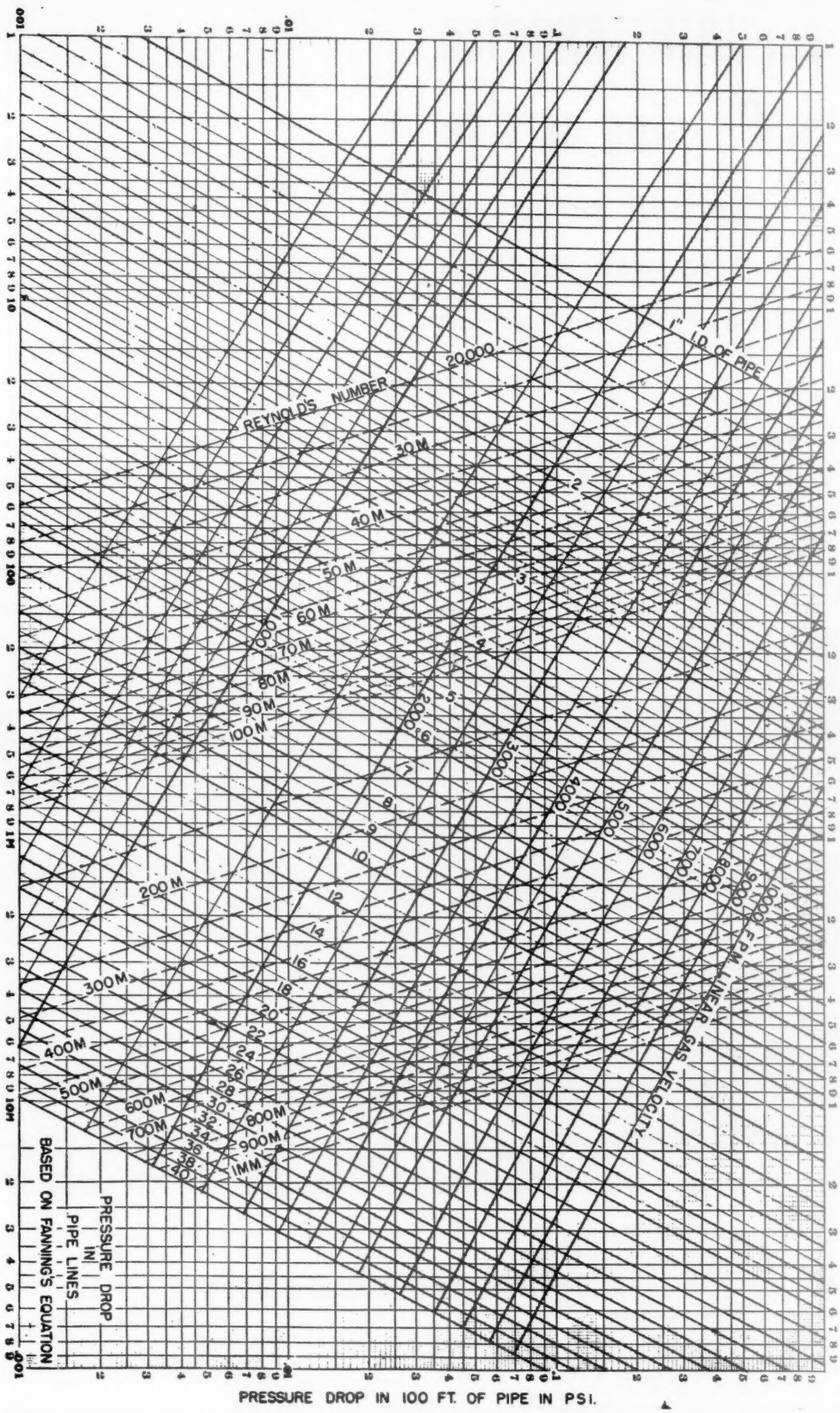
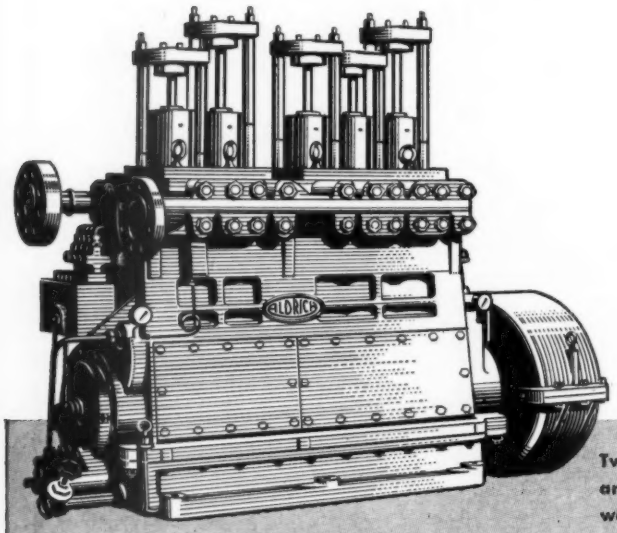
PRESSURE DROP IN GAS PIPE LINES



From article by B. C. Thiel, Cooper-Bessemer Corporation, *Calculating Pipe Sizes for Compressor Cylinders*, *The Petroleum Engineer*, November, 1943.

For UNINTERRUPTED water flooding service

. . . it will pay you to use Aldrich Direct Flow Pumps

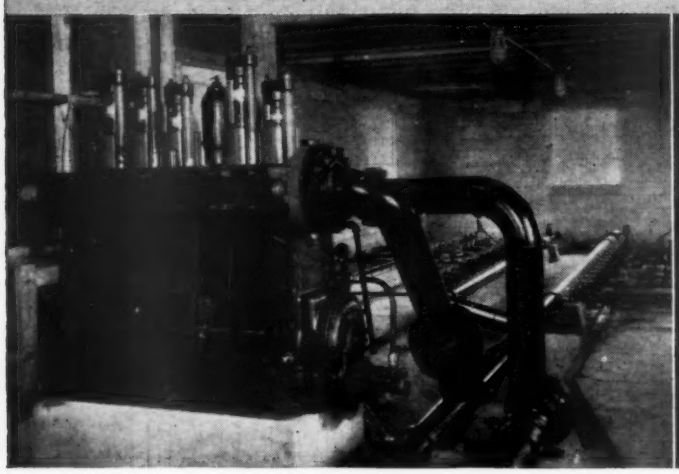


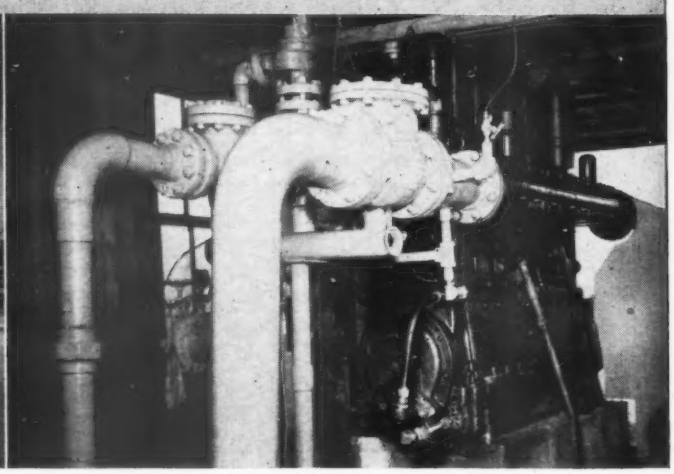
Their record will tell you why. On a large number of water flood projects throughout the country, Aldrich Pumps are providing continuous operation at high pressure . . . critical "musts" in this form of secondary recovery. Operators have found them not only dependable, but also highly efficient.

For water flooding Aldrich can supply you with a pump to meet any volume or pressure requirements you may have. Aldrich Pumps range from a 3"-50 hp triplex, through 5" triplex and multiplex, to the 6" series ranging up to 900 hp.

Get in touch with your nearest Aldrich Representative . . . or write us directly. Data sheets are always available upon request.

Two Aldrich Direct Flow Pumps on the job on water flood operations. At left is an Aldrich 5" stroke motor-driven Quintuplex Pump used for pumping salt water at the Osage #2 property of Winona Oil Company, Flat Rock, Okla. On the right is an installation at Skiles Oil Company, Mt. Carmel, Ill., where a similar Aldrich unit pumps fresh water at 120 gpm against 1450 psi.





THE ALDRICH PUMP COMPANY

26 PINE STREET • ALLENTOWN, PENNSYLVANIA

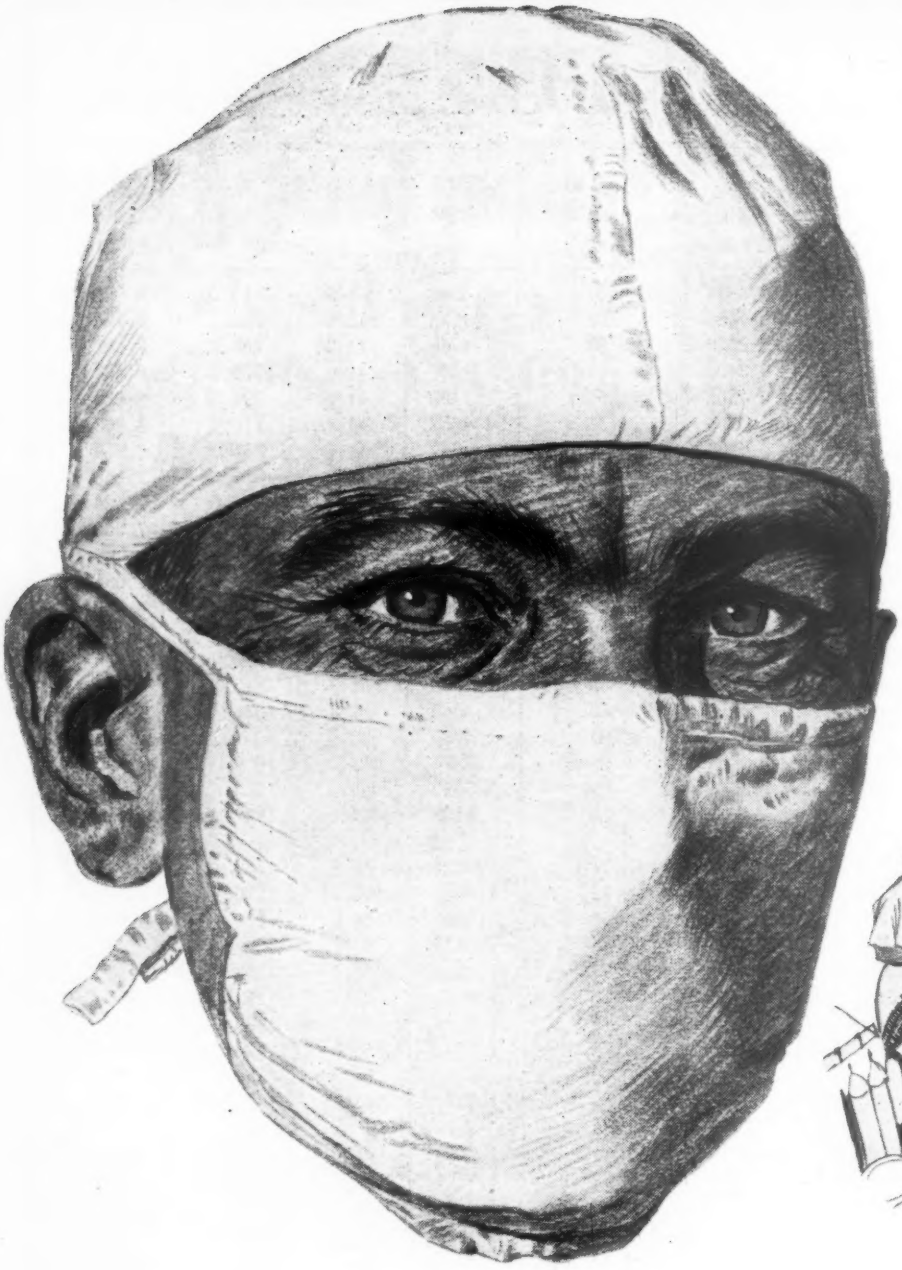
. . . Originators of the Direct Flow Pump

Representatives: P. H. Arden, P. O. Box 185, Glenview, Ill. • Bushnell Controls & Equipment Co., 3929 W. Jefferson Blvd., Los Angeles 16, Calif. • L. T. Gibbs, 509 Petroleum Bldg., Tulsa 3, Okla. • R. B. Moore Supply Co., Inc., Bolivar, N. Y. • Power Specialty Co., 2000 Kipling St., Houston 6, Texas • Reeves & Skinner Machinery Co., 2211 Olive St., St. Louis 3, Mo. Stearns-Roger Manufacturing Co., 1720 California St., Denver 2, Colo. • Export Sales: Petroleum Machinery Corp., 30 Rockefeller Plaza, New York 20, N. Y. • Birmingham • Boston Buffalo • Cincinnati • Cleveland • Detroit • Duluth • Jacksonville • Omaha • Philadelphia • Pittsburgh • Portland, Ore. • Richmond, Va. • San Francisco • Seattle • Spokane, Wash. • Syracuse

DENSITY AND ACID CONTENT OF SULPHURIC ACID SOLUTIONS (20° C or 68° F)

Weight percent H_2SO_4	Sp. gr.	Gravity, deg. Bé.	Grams H_2SO_4 per liter	Lb. H_2SO_4 per gal.	Weight percent H_2SO_4	Sp. gr.	Gravity, deg. Bé.	Grams H_2SO_4 per liter	Lb. H_2SO_4 per gal.
1	1.0051	0.7	10.05	0.0839	51	1.4049	41.8	716.5	5.979
2	1.0118	1.7	20.24	0.1689	52	1.4148	42.5	735.7	6.140
3	1.0184	2.6	30.55	0.2550	53	1.4248	43.2	755.1	6.302
4	1.0250	3.5	41.00	0.3422	54	1.4350	44.0	774.9	6.467
5	1.0317	4.5	51.59	0.4305	55	1.4453	44.7	794.9	6.634
6	1.0385	5.4	62.31	0.5200	56	1.4557	45.4	815.2	6.803
7	1.0453	6.3	73.17	0.6106	57	1.4662	46.1	835.7	6.974
8	1.0522	7.2	84.18	0.7025	58	1.4768	46.8	856.5	7.148
9	1.0591	8.1	95.32	0.7955	59	1.4875	47.5	877.6	7.324
10	1.0661	9.0	106.6	0.8897	60	1.4983	48.2	899.0	7.502
11	1.0731	9.9	118.0	0.9851	61	1.5091	48.9	920.6	7.682
12	1.0802	10.8	129.6	1.082	62	1.5200	49.6	942.4	7.865
13	1.0874	11.7	141.4	1.180	63	1.5310	50.3	964.5	8.049
14	1.0947	12.5	153.3	1.279	64	1.5421	51.0	986.9	8.236
15	1.1020	13.4	165.3	1.379	65	1.5533	51.7	1010	8.426
16	1.1094	14.3	177.5	1.481	66	1.5646	52.3	1033	8.618
17	1.1168	15.2	189.9	1.584	67	1.5760	53.0	1056	8.812
18	1.1243	16.0	202.4	1.689	68	1.5874	53.7	1079	9.008
19	1.1318	16.9	215.0	1.795	69	1.5989	54.3	1103	9.207
20	1.1394	17.7	227.9	1.902	70	1.6105	55.0	1127	9.408
21	1.1471	18.6	240.9	2.010	71	1.6221	55.6	1152	9.611
22	1.1548	19.4	254.1	2.120	72	1.6338	56.3	1176	9.817
23	1.1626	20.3	267.4	2.231	73	1.6456	56.9	1201	10.02
24	1.1704	21.1	280.9	2.344	74	1.6574	57.5	1226	10.24
25	1.1783	21.9	294.6	2.458	75	1.6692	58.1	1252	10.45
26	1.1862	22.8	308.4	2.574	76	1.6810	58.7	1278	10.66
27	1.1942	23.6	322.4	2.691	77	1.6927	59.3	1303	10.88
28	1.2023	24.4	336.6	2.809	78	1.7043	59.9	1329	11.09
29	1.2104	25.2	351.0	2.929	79	1.7158	60.5	1355	11.31
30	1.2185	26.0	365.6	3.051	80	1.7272	61.1	1382	11.53
31	1.2267	26.8	380.3	3.173	81	1.7383	61.6	1408	11.75
32	1.2349	27.6	395.2	3.298	82	1.7491	62.1	1434	11.97
33	1.2432	28.4	410.3	3.424	83	1.7594	62.6	1460	12.19
34	1.2515	29.1	425.5	3.551	84	1.7693	63.0	1486	12.40
35	1.2599	29.9	441.0	3.680	85	1.7786	63.5	1512	12.62
36	1.2684	30.7	456.6	3.811	86	1.7872	63.9	1537	12.83
37	1.2769	31.4	472.5	3.943	87	1.7951	64.2	1562	13.03
38	1.2855	32.2	488.5	4.077	88	1.8022	64.5	1586	13.23
39	1.2941	33.0	504.7	4.212	89	1.8087	64.8	1610	13.43
40	1.3028	33.7	521.1	4.349	90	1.8144	65.1	1633	13.63
41	1.3116	34.5	537.8	4.488	91	1.8195	65.3	1656	13.82
42	1.3205	35.2	554.6	4.628	92	1.8240	65.5	1678	14.00
43	1.3294	35.9	571.6	4.770	93	1.8279	65.7	1700	14.19
44	1.3384	36.7	588.9	4.914	94	1.8312	65.8	1721	14.36
45	1.3476	37.4	606.4	5.061	95	1.8337	65.9	1742	14.54
46	1.3569	38.1	624.2	5.209	96	1.8355	66.0	1762	14.70
47	1.3663	38.9	642.2	5.359	97	1.8364	66.0	1781	14.87
48	1.3758	39.6	660.4	5.511	98	1.8361	66.0	1799	15.02
49	1.3854	40.3	678.8	5.665	99	1.8342	65.9	1816	15.15
50	1.3951	41.1	697.6	5.821	100	1.8305	65.8	1831	15.28

The Baumé scale is that for liquids having density greater than that of water.



Oil helps him keep us healthy...

What makes a doctor? Long years of learning, a deft pair of hands, eyes that see beneath the surface, a mind that must make life-or-death decisions in a clock's tick. Working hours: 24 a day. Responsibility: unlimited. Petroleum, so useful in so many fields, is helping the doctor, too. A lot of his "magic" aids – such as antiseptics, drugs, sedatives, dressings – are produced from this vital resource. Through continuous research and superior petroleum products, The Texas Company has long served our country's medical profession.

The Texas Company

TEXACO

SPECIFIC GRAVITY OF SULPHURIC ACID SOLUTIONS AT VARIOUS TEMPERATURES

Weight percent of H_2SO_4	Temperature of solution										
	0° C 32° F	10° C 50° F	15° C 59° F	20° C 68° F	25° C 77° F	30° C 86° F	40° C 104° F	50° C 122° F	60° C 140° F	80° C 176° F	100 °C 212° F
51	1.4209	1.4128	1.4088	1.4049	1.4009	1.3970	1.3893	1.3816	1.3740	1.3590	1.3444
52	1.4310	1.4228	1.4188	1.4148	1.4109	1.4069	1.3991	1.3914	1.3837	1.3687	1.3540
53	1.4412	1.4329	1.4289	1.4248	1.4209	1.4169	1.4091	1.4013	1.3936	1.3785	1.3637
54	1.4515	1.4431	1.4391	1.4350	1.4310	1.4270	1.4191	1.4113	1.4036	1.3884	1.3735
55	1.4619	1.4535	1.4494	1.4453	1.4412	1.4372	1.4293	1.4214	1.4137	1.3984	1.3834
56	1.4724	1.4640	1.4598	1.4557	1.4516	1.4475	1.4396	1.4317	1.4239	1.4085	1.3934
57	1.4830	1.4746	1.4703	1.4662	1.4621	1.4580	1.4500	1.4420	1.4342	1.4187	1.4035
58	1.4937	1.4852	1.4809	1.4768	1.4726	1.4685	1.4604	1.4524	1.4446	1.4290	1.4137
59	1.5045	1.4959	1.4916	1.4875	1.4832	1.4791	1.4708	1.4629	1.4551	1.4393	1.4240
60	1.5154	1.5067	1.5024	1.4983	1.4940	1.4898	1.4816	1.4735	1.4656	1.4497	1.4344
61	1.5264	1.5177	1.5133	1.5091	1.5048	1.5006	1.4923	1.4842	.4762	1.4602	1.4449
62	1.5375	1.5287	1.5243	1.5200	1.5157	1.5115	1.5031	1.4950	1.4869	1.4708	1.4554
63	1.5487	1.5398	1.5354	1.5310	1.5267	1.5225	1.5140	1.5058	1.4977	1.4815	1.4660
64	1.5600	1.5510	1.5465	1.5421	1.5378	1.5335	1.5250	1.5167	1.5086	1.4923	1.4766
65	1.5714	1.5623	1.5578	1.5533	1.5490	1.5446	1.5361	1.5277	1.5195	1.5031	1.4873
66	1.5828	1.5736	1.5691	1.5646	1.5602	1.5558	1.5472	1.5388	1.5305	1.5140	1.4981
67	1.5943	1.5850	1.5805	1.5760	1.5715	1.5671	1.5584	1.5499	1.5416	1.5249	1.5089
68	1.6059	1.5965	1.5920	1.5874	1.5829	1.5785	1.5697	1.5611	1.5528	1.5359	1.5198
69	1.6176	1.6081	1.6035	1.5989	1.5944	1.5899	1.5811	1.5724	1.5640	1.5470	1.5307
70	1.6293	1.6198	1.6151	1.6105	1.6059	1.6014	1.5925	1.5838	1.5753	1.5582	1.5417
71	1.6411	1.6315	1.6268	1.6221	1.6175	1.6130	1.6040	1.5952	1.5867	1.5694	1.5527
72	1.6529	1.6433	1.6385	1.6338	1.6292	1.6246	1.6155	1.6067	1.5981	1.5806	1.5637
73	1.6648	1.6551	1.6503	1.6456	1.6409	1.6363	1.6271	1.6182	1.6095	1.5919	1.5747
74	1.6768	1.6670	1.6622	1.6574	1.6526	1.6480	1.6387	1.6297	1.6209	1.6031	1.5857
75	1.6888	1.6789	1.6740	1.6692	1.6644	1.6597	1.6503	1.6412	1.6322	1.6142	1.5966
76	1.7008	1.6908	1.6858	1.6810	1.6761	1.6713	1.6619	1.6526	1.6435	1.6252	1.6074
77	1.7128	1.7026	1.6976	1.6927	1.6878	1.6829	1.6734	1.6640	1.6547	1.6361	1.6181
78	1.7247	1.7144	1.7093	1.7043	1.6994	1.6944	1.6847	1.6751	1.6657	1.6469	1.6286
79	1.7365	1.7261	1.7209	1.7158	1.7108	1.7058	1.6959	1.6862	1.6766	1.6575	1.6390
80	1.7482	1.7376	1.7323	1.7272	1.7221	1.7170	1.7069	1.6971	1.6873	1.6680	1.6493
81	1.7597	1.7489	1.7435	1.7383	1.7331	1.7279	1.7177	1.7077	1.6978	1.6782	1.6594
82	1.7709	1.7599	1.7544	1.7491	1.7437	1.7385	1.7281	1.7180	1.7080	1.6882	1.6692
83	1.7815	1.7704	1.7649	1.7594	1.7540	1.7487	1.7382	1.7279	1.7179	1.6979	1.6787
84	1.7916	1.7804	1.7748	1.7693	1.7639	1.7585	1.7479	1.7375	1.7274	1.7072	1.6878
85	1.8009	1.7897	1.7841	1.7786	1.7732	1.7678	1.7571	1.7466	1.7364	1.7161	1.6966
86	1.8095	1.7983	1.7927	1.7872	1.7818	1.7763	1.7657	1.7552	1.7449	1.7245	1.7050
87	1.8173	1.8061	1.8006	1.7951	1.7897	1.7842	1.7736	1.7632	1.7529	1.7324	1.7129
88	1.8243	1.8132	1.8077	1.8022	1.7968	1.7914	1.7809	1.7705	1.7602	1.7397	1.7202
89	1.8306	1.8195	1.8141	1.8087	1.8033	1.7979	1.7874	1.7770	1.7669	1.7464	1.7269
90	1.8361	1.8252	1.8198	1.8144	1.8091	1.8038	1.7933	1.7829	1.7729	1.7525	1.7331
91	1.8410	1.8302	1.8248	1.8195	1.8142	1.8090	1.7986	1.7883	1.7783	1.7581	1.7388
92	1.8453	1.8346	1.8293	1.8240	1.8188	1.8136	1.8033	1.7932	1.7832	1.7633	1.7439
93	1.8490	1.8384	1.8331	1.8279	1.8227	1.8176	1.8074	1.7974	1.7876	1.7681	1.7485
94	1.8520	1.8415	1.8363	1.8312	1.8260	1.8210	1.8109	1.8011	1.7914		
95	1.8544	1.8439	1.8388	1.8337	1.8286	1.8236	1.8137	1.8040	1.7944		
96	1.8560	1.8457	1.8406	1.8355	1.8305	1.8255	1.8157	1.8060	1.7965		
97	1.8569	1.8466	1.8414	1.8364	1.8314	1.8264	1.8166	1.8071	1.7977		
98	1.8567	1.8463	1.8411	1.8361	1.8310	1.8261	1.8163	1.8068	1.7976		
99	1.8551	1.8445	1.8393	1.8342	1.8292	1.8242	1.8145	1.8050	1.7958		
100	1.8517	1.8409	1.8357	1.8305	1.8255	1.8205	1.8107	1.8013	1.7922		

LAUGH with BARNEY

Judge: "What possible excuse did you fellows have for acquitting that murderer?"
Jury Foreman: "Insanity."
Judge: "What! All 12 of you?"

Sign in a Plant: "Women, Caution! If your clothes are too loose, beware of the machinery. If too tight, beware of the workmen."

Pedestrian to newsboy: "Son, can you direct me to the nearest bank?"
Newsboy: "Yes, sir, for a quarter."
Pedestrian: "Isn't that high pay, my boy?"
Newsboy: "No, sir, not for a bank director."

One of the worst tragedies that can befall a man is to have ulcers and still not be a success.

Friend: "I saw a young man trying to kiss your daughter last night."
Mother: "Did he succeed?"
Friend: "No."
Mother: "Then it wasn't my daughter."

"Let's organize a fraternity."
"Why?"
"I've just discovered a new grip."

An inmate in an insane asylum was troubled with the notion he had a cat in his belly. It tore around inside and clawed him up something fierce. One day the fellow got a real pain—his appendix had to come out. The doctor figured here was a chance to cure the patient of his cat notion.

A real cat was obtained, a lively black one, and when the patient came out of the ether the doctor held up the animal and said: "You're all right now. Look what we took out of you."

The patient took one look, grabbed his tummy and howled: "You got the wrong cat; the one that's bothering me is a grey one."

"This examination will be conducted on the honor system," the professor announced. "Please take seats three apart and in alternate rows."

Coach: "Cutie, what are you doing with that letter on your sweater? Don't you know you're supposed not to wear that unless you've made the team?"
Cutie: "Well?"

"Do I really need brushing off?" asked the passenger in the Pullman.
"Does you!" exclaimed the porter with great emphasis. "Boss, I'se broke!"

"It's oil....LANE-WELLS on the job."

"Rastus," spoke up the best man, "what for you tremblin' so much 'bout? Has you lost de ring?"
"Naw, sir, I'se got de ring, I'se got de license, I'se got de preacher, but I'se done lost mash 'thoosiasm."

The girl with the most sex appeal in all America: "Miss Depression"—She's been felt by everyone.

Nothing is so broadening to man as travel, and to a woman as a pair of ski trousers.—English Digest.

THE WILDCAT

Running high and looking good,
Just like wildcats do and should,
Fifty feet and sometimes higher
It fills the owner's soul with fire.

Although there's a stretch in every line,
It's running high and looking fine.
The driller often slips a string
But that is just a trifling thing.

They cut a sand line, make a splice
But only do it once or twice,
They use a steel line in a pinch—
The Driller's never off an inch.

Geologists now take the dope,
And with a shining microscope,
They study sand, and shale, and lime,
To think this out takes lots of time.

With their colossal brains they ponder,
Mouth-opened farmers stand and wonder,
Lease brokers stand in line and wait,
He speaks, "She's running high, looking great."

A thrill that shakes the very ground—
They're gone before you look around—
Royalties and leases sell
She's running high and looking swell.

Three months have passed—another scene,
The Rig is gone, the grass is green.
The gaping slush pit, cracked and dried,
An optimist, here, fought and died.

So thus it is with wildcat wells,
They're spudded in with clanging bells.
When plugged and shouts of joy have died,
You wonder who in hell has lied.
—Unknown

The difference between a married man and a bachelor is that when a bachelor walks the floor with a babe in his arms he's trying to sober her up.

First Coed: "Why are you straightening up the room?"
Second Coed: "I read in the paper that two girls were arrested for keeping a disorderly house."

Golfer: "You'll drive me out of my mind."
Wife: "That would be a putt, dear—hardly a drive."

OIL and GAS TRADE NEWS

R. L. Harris

G. A. Metz

C. W. Crabtree

A. T. Skaer

Mid-Continent Office Set Up in Canada

Mid-Continent Supply Company has opened division offices and is building a new store in the province of Alberta. Canada, Ken W. Davis, president, announced recently.

Division offices have been opened in the Blow Building in Calgary. The new store in Edmonton should be complete in early August.

Transferred to Calgary as division manager is R. L. Harris. Accompanying him is division machinery manager, G. A. Metz. Manager C. W. Crabtree is in Edmonton supervising construction. All three men were formerly situated at Casper, Wyoming.

Along with the Alberta move, Mid-Continent has transferred former assistant division manager, A. T. Skaer of Tulsa to Denver as division manager.

Wilson Supply Will Be Agent

S. C. Carter Company, Inc., Los Angeles, manufacturers of the Carter long-stroke hydrualic pumping unit, announces the appointment of Wilson Supply as distributor for South Texas.

New Distributors Named

The Rust-Oleum Corporation announces the addition of two new industrial distributors to its nation-wide distributor sales organization. The newly appointed distributor firms are: Griswold-Sohl Automotive Company, 232 North Fourth Street. Columbus 15, Ohio; and Mill Supplies, Incorporated, Box 2762, Highway 82, East, Greenville, Mississippi.

Republic Opens New Seamless Tube Mill

Republic Steel Corporation officially opened a new seamless tube mill at its South Chicago steel plant recently. Put into operation after nearly two years of construction, the new seamless tube mill rounds out Republic's broad line of tube and pipe products.

Manager of Republic's Chicago district is C. P. Cutler, who began his career in the steel industry 44 years ago as an office boy with a Republic predecessor company. P. M. Murphy and W. M. Farnsworth are assistant district managers. Superintendent of the seamless tube mill is B. C. Barton.

Quaker Rubber Warehouse Established in New Orleans

A new, stock carrying branch warehouse and sales office has been established by Quaker Rubber Corporation, Division of H. K. Porter Company, Inc., at 2840 N. Claiborne Street, New Orleans, Louisiana, it was announced by G. A. Dauphinais, vice president and general manager.

New branch is under the supervision of Morgan Kather.

Brown Mud Named Palcotan Sales Distributor

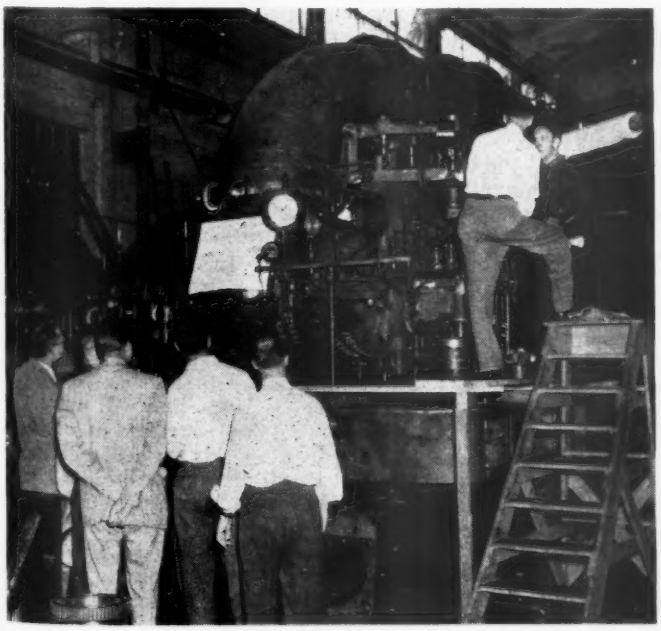
Brown Mud Company has been appointed as Pacific Coast sales representative for Palcotan drilling mud additive, according to The Pacific Lumber Company, manufacturer of the product. Palcotan is used to reduce viscosity and control gel strength and water loss of drilling muds. The firm is headed by George M. Brown.

Ideco Pumping Line Bought

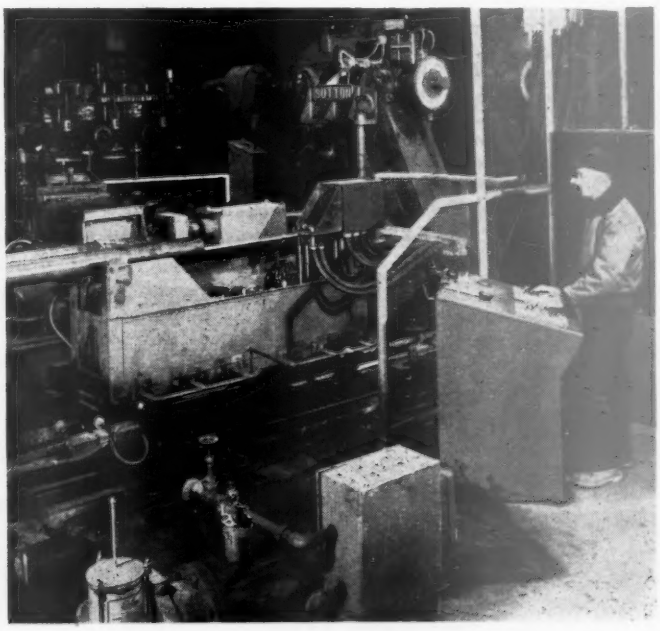
Alten Foundry and Machine Works announces the purchase of the Ideco pumping unit line from Dresser Industries. The Lancaster, Ohio, firm will continue the manufacture of Ideco type pumping units and provide spare parts and service for those Ideco units already in the field.

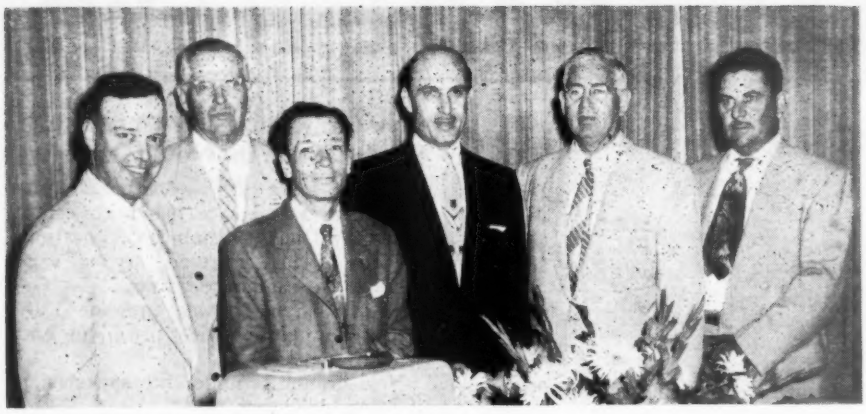
Alten, by combining its present models with those heretofore built by Ideco, now offers oil operators a complete line of pumping units including all API sizes. Alten units and Alten Ideco type units are available through supply stores in keeping with policy of the Lancaster, Ohio Equipment Company.

COMMUNITY LEADERS attend De Laval Steam Turbine Company's open house tour of steam turbines, speed reducers, centrifugal compressors produced for a world market by the company.



REPUBLIC STEEL'S X-ray thickness gage used to test seamless tubing at its new South Chicago seamless tube mill. Device consists of a traveling carriage on which an X-ray probe is mounted.





TED WORKMAN of Ted Workman Advertising (center, dark suit), Dallas, Texas, surrounded by clients who attended testimonial dinner for him. Event was staged by clients and suppliers in honor of the election of Workman's agency to AAAA. With Workman, left to right, are: Bud Hilker, advertising manager Eastman Oil Well Supply Company, Denver, Colorado, Aubrey Wilson, general sales manager Wilson Manufacturing Company, Inc., Wichita Falls, Texas, Harry Lemmons, president, Saladmaster Sales, Inc., Dallas, Texas, John Wilson, president, Wilson Manufacturing, Wichita Falls, and Charles Murray, Lake Whitney Enterprises, Whitney, Texas.

Amercoat Moves to Houston

Amercoat Corporation has re-located its branch offices and warehouse in new and larger quarters at Houston, Texas, according to G. E. Seidel, executive vice president of the company. The new branch offices, opened June 1, are situated at 6530 Supply Row in Houston's expanding Supply Row Center industrial area.

Lucien L. Miner, Amercoat district manager, will be in charge of operations at the new location. Amercoat formerly maintained its south central branch at Dallas.

"WE'RE BUSTIN' OUT ALL OVER!"

If it's action you want, whether your needs are Packings, Piston Rings or Valve Discs for use as original equipment, for routine replacement or when critical conditions require IMMEDIATE SUPPLY, France is 'bustin' out all over' with production and technical facilities to serve you.

Write for Complete Information

- Metallic Packings
- Power Piston Rings
- Carbon-Bakelite Liquid Pump & Compressor Piston Rings
- Valve Discs

FRANCE PACKING COMPANY

6512 STATE RD., PHILADELPHIA 35, PA.

Israel Fair Shows Use of Machinery in Negev Desert

Israel's Conquest of the Desert International Exhibit and Fair, which is presenting during July 16-August 17 in Jerusalem, the progress made in land reclamation in the Negev desert, will also feature the results of the role played by American machinery in land reclamation. In one part of Negev, large centrifugal pumps manufactured by De Laval Steam Turbine Company of Trenton, New Jersey, are being installed.

R. E. Chase Will Handle Centrifugal Pump Line

The R. E. Chase Company of Tacoma, Washington, has been appointed a distributor for centrifugal pumps manufactured by Mission Manufacturing Company, Houston, Miller Sparks, manager of the centrifugal pump division of Mission, has announced.

Porter Acquires Control Of A. Leschen and Sons

H. K. Porter Company, Inc., Pittsburgh, has acquired a controlling interest in A. Leschen and Sons Rope Company, St. Louis, Missouri, T. M. Evans, president of Porter, stated. The Leschen Company, established in 1857, is one of the country's oldest producers of wire rope. The company supplies wire rope for oil and gas drilling, elevators, marine uses, derricks and cranes, bridges, water well and blast hole drilling, rope slings, and many other purposes. Operations will continue as Leschen Wire Rope Company, a Division of H. K. Porter Company, Inc., under the direction of D. W. Vernon, vice president and general manager. A. A. Leschen, former president, has expressed a desire to retire from active business.

Glass Fibrous Products Sold by Kelley Asbestos

Kelley Asbestos Products Company, Kansas City, Missouri, has been named distributors for glass fibrous products manufactured by Gustin-Bacon Manufacturing Company of Kansas City. The Kelley Company will be exclusive Kansas City distributors of Ultralite—a thermal and acoustical insulation of long glass fibers that is widely used throughout industry for duct insulation, metal buildings, trucks and trailers, and original equipment of all types. It will also distribute Ultrafine, a blanket type thermal and acoustical insulation of fine glass fibers, and Ultrafine Pipe Insulation—Gustin-Bacon's new one-piece pipe insulation molded of glass fibers.

Annealing Equipment Is Installed at CF&I Mill

New annealing equipment has been installed at The Colorado Fuel and Iron Corporation's fully-integrated steel mill at Pueblo, Colorado. This equipment will double the plant's capacity for the production of pot annealed wire, according to A. F. Franz, president of the corporation. New annealers will supply wire to additional coiling equipment for final processing into standard 48-lb and 100-lb coils of automatic baling machine wire. In cooperation with equipment manufacturers and the American Society of Agricultural Engineers, baling wire coils have been standardized at 14½ gage with coil lengths of 3150 and 6500 ft.

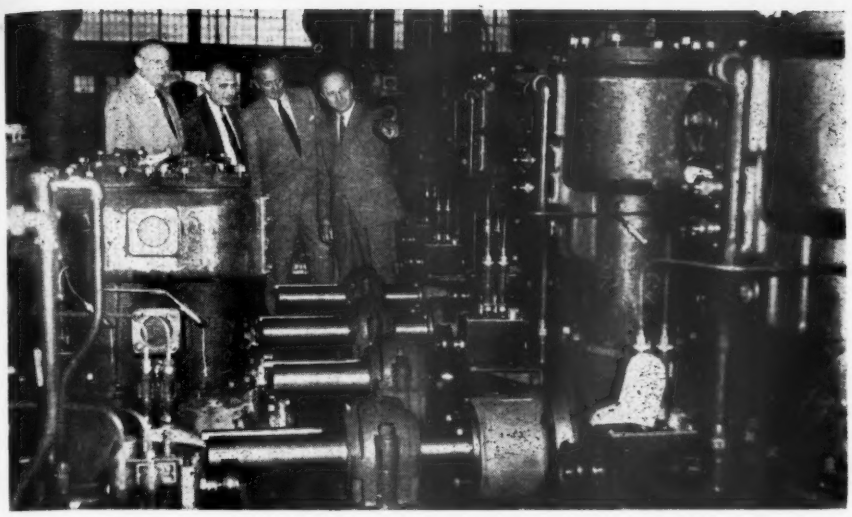
Johnson Named to Lane-Wells Post

W. A. Johnson has been appointed district superintendent of Lane-Wells North Central Texas district and has been transferred to Wichita Falls. He was formerly district superintnedent of Southwest Texas. W. W. Wilson has been appointed assistant district superintendent of Southwest Texas district, and will be stationed in Alice. In turn, G. A. Harris, who has returned from Petro-tech service Company in Venezuela, has been named sub district superintendent in Corpus Christi to fill the former post of W. W. Wilson.

R. E. Parmley of Lane-Wells Company has been appointed superintendent of the Hobbs, New Mexico, station. In his new assignment, Parmley wlil report to the sub district sperintendent of the Hobbs base.

Pearson Retires as VP

Robert H. Pearson, who has been associated with Gardner-Denver Company for 37 years, has retired as a vice president of the company, and will move to Denver to assume management of Air Rentals, Inc., a newly formed organization which will distribute Gardner-Denver equipment and several allied lines of equipment and supplies for mining and construction. Pearson joined the Denver Rock Drill Company in Denver, Colorado, in 1916, and became associated with Garden-Denver in 1927.



INTERNATIONAL SALES CONFERENCE marked Worthington Corporation's 100th year in export trade. Conference members included managing directors and executives of the company's overseas operations. Above, Horace Wood, assistant general manager, export department; J. J. Thompson, manager, personnel department; C. J. Andriessen, and E. Blanchart, look at ammonia refrigeration compressors during tour of Buffalo Works. Andriessen and Blanchart are distributors in the Netherlands and Be'gium, respectively.

Reed Completes New Shop

A 43,000-sq ft addition to Reed Roller Bit Company's Houston, Texas, plant has recently been completed. The new shop will flash weld tool joints to drill pipe, latest addition to Reed's line of oil tools.

More than 50 Reed division managers and salesmen from all over the United States, Canada, Mexico, and South America, were brought to Houston for a three-day session to inspect the new plant and watch it in operation.

Colorado Office Opened

Carleton Clymer

Grove Regulator Company has opened a new office in Denver, Colorado. Named as district manager in charge of the office is Carleton Clymer. Grove maintains manufacturing plants in Oakland, California, and Houston, Texas. The new office will round out a network of sales offices in principal cities serving the industry.

Shand and Jurs Expands

Ralph F. Ley

Shand and Jurs Company has moved to greatly enlarged quarters at 342 Madison Street, in Berkeley, California. The move was made necessary by the increased personnel required to handle a steadily increasing volume of business, not only with domestic producers, but with foreign producres as well. Ralph F. Ley is manager of the New York office and Joseph T. Drumm assistant manager.

New Sales Field Opened

A new sales field has been opened by The French Jordan and White Fishing Tool Service Company, Harvey, Louisiana. J. B. "Budd" Lewis has been appointed representative for Louisiana, Arkansas, Texas and Mississippi. Lewis formerly associated with a national oil tool company, has been an operator and supervisor for more than 12 years.

Cleco Appoints Distributors

The Cleco Division of the Reed Roller Bit Company, Houston, Texas, has announced the appointment of La Grand Industrial Supply Company, 15 S. W. Arthur Street, Portland 1, Oregon; The Sidney B. Roby Company, 208-214 South Avenue, Rochester, New York; and Fehrs Tractor and Equipment Company, Inc., 1809-11 Cuming Street, Omaha 2, Nebraska, as distributors for Cleco products in their areas.

Insul-Mastic Signs Licensees

A western and a southern insulation contractor have accepted licensee contracts with the Insul-Mastic Corporation of America. The companies are: The Starr Davis Company, Inc., of Greensboro, North Carolina, and the Plant Asbestos Company of Emeryville, California.

Elliott Office Moves

Elliott Company's district office in Tulsa, Oklahoma, has been moved from 616 McBirney Building, where it has been for many years, to 910 Petroleum Building. W. S. Carlson has been appointed manager of the Minneapolis district office of Elliott Company at 540 Plymouth Building. A graduate of the University of Minnesota, he joined Elliott in June, 1951.

H. D. Mateffy has been appointed branch manager of the Duluth office of Elliott Company.

Efficient, dependable pumps noted for endurance and high records of performance. They serve tank trucks, refineries, process plants and general industries — they will do an equally productive job for you. Series 3600 pumps feature hardened helical pumping gears, high-lead bronze bearings, split packing gland, adjustable relief valve. Standard or special fitted models; pressures to 60 P.S.I. — capacities 40 to 300 G.P.M.

Send for Booklet "HOW TO SOLVE PUMPING PROBLEMS"

ROPER Rotary Pumps

SEE OUR CATALOG IN SWEET'S

GEO. D. ROPER CORP.
728 Blackhawk Park Ave.
ROCKFORD, ILL.

TRADE PERSONALS

Montgomery R. Budd was named director of advertising for Hercules Powder Company. He succeeds **Theodore Marvin,** who resigned to become president of the Michigan Chemical Corporation of St. Louis, Michigan. Budd joined the company in 1929.

C. H. Murphy has been added to the Perrault Equipment Company staff as administrative manager. Murphy was general manager of a machine shop in Wichita, Kansas, from 1949 until 1951 when the shop was bought by Continental Can Company.

Philip H. Moore, Albany House, Esplanade, Durban, Natal, has been named sales and service representative for Southern Africa, for T. D. Williamson, Inc. Moore is a graduate of the University of Birmingham, England.

J. Carl Bland, salesman with the Carboloy Department of General Electric Company, has been transferred from the St. Louis, Missouri, area to a new territory covering Texas and Louisiana. Bland is a graduate of Wayne University in Detroit.

John B. Spence was recently named by The Continental Supply Company to head its advertising and sales promotion division. Spence assumes these duties from **A. J. Mueller,** who has supervised the advertising activities in addition to his work in connection with catalogs and pricing. Spence is a graduate of Oklahoma University, journalism school.

Glenn G. Chance, formerly of the engineering department of Lee C. Moore Corporation in Tulsa, is now sales engineer for the company. He will be stationed in Shreveport, Louisiana.

Ned Rodgers, assistant chief engineer for American Iron and Machine Works Company of Oklahoma City, has recently returned from an extended sales and engineering trip to Venezuela.

L. D. Campbell

L. B. Meaders

R. G. Kelly

M. Brummett

H. H. Leonard

D. R. Yager

Logan D. Campbell, vice president and secretary-treasurer of Halliburton Oil Well Cementing Company, assumes the newly-created post of vice chairman of the company, assistant to Erle P. Halliburton. He was re-elected as director.

L. B. "Preach" Meaders, vice president for field operations, succeeds **W. R. McClendon** who retired as president after 30 years association with Halliburton. Meaders was elected a director at the annual meeting in Dallas, Texas, recently.

Taking over Meaders' former post as vice president for field operations is **R. G. Kelly,** who has been one of Halliburton's regional vice presidents.

Marvin Brummett, assistant general counsel of the company since 1947, was named secretary of the company. **H. H. "Spike" Leonard,** assistant secretary treasurer since 1940, becomes treasurer and assistant secretary. One new vice president was named. He is **D. R. Yager,** manager of Halliburton's Oklahoma division, who succeeds Kelly as a regional vice president.

All of the officials named, except Yager, now live in Duncan. Yager is moving from Oklahoma City to Duncan. All other officers of the company were re-elected at the Dallas meeting.

C. L. Norton

W. O. Cook

W. F. Goertz

L. C. Johnston

P. A. Coffman

J. Oostermeyer

P. A. Kneiff

C. L. "Chet" Norton has been added to the sales force of Armite Laboratories. He has formerly been connected with the sales department of Coca Cola Bottling Company of Los Angeles for the last 17 years.

W. O. Cook has been promoted to a vice president of the Ideco Division, of Dresser Industries, Inc. Cook joined Ideco in 1934 as design engineer and from 1940 to November, 1946 was director of engineering. He was appointed assistant general manager and later succeeded **Richard R. Bloss** as general manager of Ideco's manufacturing plant at Beaumont. Cook is a graduate of Rice Institute in Houston.

Willard F. Goertz has been named general sales manager of the Axelson Manufacturing Company, division of the Pressed Steel Car Company, Inc. Joining Axelson petroleum equipment division soon after graduation from UCLA in 1927, Goertz has served continuously with the company since then.

Laurence C. Johnston has been named vice president of Brown Fintube Company. He will continue to manage sales of heat exchangers and all other Brown Fintube heat transfer equipment in the Eastern territory, with offices at 522 Fifth Avenue, New York City. Johnston joined Brown Fintube as Eastern district sales manager in 1949.

Paul A. Coffman recently was elected vice president of Omega Machine Company. Coffman came to the Omega Machine Company in 1934, following a brief period in retail selling.

Jan Oostermeyer, former president of the Shell Chemical Corporation, has been elected to the board of directors of the Fluor Corporation, Ltd., of Los Angeles, bringing the number of board members to 10.

Pat A. Knieff has joined the Iverson organization as city salesman in the Dallas, Texas, area. Knieff is well known in the industry, having formerly been connected with such firms as Jarecki, Ideco, and Bethlehem Supply Company.

Barney E. Ates, representative for McEvoy Company of Houston, has recently transferred to Houma, Louisiana, where he will make his headquarters, aiding oil company personnel in the problems dealing with high pressure valves and well head equipment.

Jack W. Harris has been named city salesman for McEvoy in Houston. Harris came to McEvoy from Cameron Iron Works, Inc., where he was assistant sales manager in charge of industrial valve division. As city salesman for McEvoy he will specialize in sales and engineering problems pertaining to the new McEvoy ASA line of valves.

M. W. "Chick" Newman has been named sales engineer and pilot of the Martin-Decker Corporation. Newman will combine selling and flying for the drilling control instrument firm, working out of the home office in Long Beach, California. Newman recently returned from Korea where he spent two years as a patrol plane commander and instructor.

Richard C. Martin has been named national sales director of Kelite Products, Inc. Martin will supervise the company's service offices in 84 cities. Martin started with Kelite in 1944 and in 1950 was put in charge of the Southern division with headquarters in Dallas.

Ransom Reynolds has been named account executive of Michel-Cather, Inc. Prior to joining Michel-Cather, Inc., Reynolds was sales manager for Gruen-Simplex Corporation, New York.

J. B. ("Benny") Murdoch recently announced his resignation from his position as technical advisor to the president of the Eastman Oil Well Survey Company. Benny entered the oil well service field in 1933 as office engineer in Long Beach, California, for Eastman. Later, he became chief engineer of the company. Two years ago, he was promoted to the position of technical advisor to the president.

Joe Safford will represent Atlas Pipe Inc., in pipe sales and finishing plant services. Safford is a graduate engineer of the University of Oklahoma and was formerly employed by the Hydril Company.

C. L. Gillespie is a new representative and sales engineer for Atlas. Gillespie has been in oil country tubular goods sales work in the Gulf Coast and Mid-Continent areas since 1937.

Joseph A. Conlon has been appointed vice president of the New York Belting and Packing Company succeeding **Ben F. Reuther**, who has retired after more than 48 years in the rubber industry. Reuther will continue in an advisory and consulting capacity. Conlon, who will function as the company's senior operating executive, was named vice president in charge of sales in October, 1952. He has been with the rubber industry since 1930.

Floyd V. Snodgrass, former general manager of the Nordstrom Valve Division plant at Oakland, California, has been appointed to a special administrative post involving supervision of production and operations at Oakland and Sulphur Springs, by Rockwell Manufacturing Company.

Replacing him as general manager at Oakland is **W. D. Willes**, who has been general manager of the company's Barberton, Ohio, plant since September, 1952. **W. T. Gettig**, former works manager of Edward Valves, Inc.—a Rockwell subsidiary—has been named general manager at Barberton.

William R. Henry has been named district manager of West Texas for Daniel Orifice Fitting Company. His headquarters will be at the company's sales offices and warehouse at Odessa. He is a graduate of the University of Texas. **W. C. (Bill) Watson** has joined the Daniel sales force at Odessa. He is well known in that area having lived in Odessa for several years.

J. R. Wilson is the new member of the Daniel sales staff at Los Angeles. For the past five years, Wilson has been technical assistant in Texas Pipe Line Division of Southern Counties Gas Company of California.

Clifford W. Michaels, Jr. is now with Dowell Incorporated where he is assisting **S. J. Martinez**, Dowell's technical editor. Michaels will aid in the preparing of technical articles and for publication and of technical papers for presentation before scientific and engineering groups. He is a graduate of University of Wichita.

Eugene D. Lawrence has been promoted to administrative assistant for Dowell. In his new assignment he will assist **C. E. Mangold**, assistant general manager, in expediting the handling the operation of Dowell's various departments located at 1150 North Utica in Tulsa. Lawrence joined Dowell in 1945.

Phillip McMorrow is transferring from the Dowell accounting department to assist Lawrence.

Frank Proctor has recently joined the sales organization of American Iron and Machine Works Company and will specialize in the promotion of production equipment.

Walt McCharen has recently been transferred from Odessa, Texas, to Abilene, Texas. McCharen worked in the engineering department of American Iron before being transferred to Odessa in 1950.

W. T. "Dusty" Biddle has been appointed district sales manager for the Rocky Mountain area. Biddle graduated from University of Oklahoma in 1948.

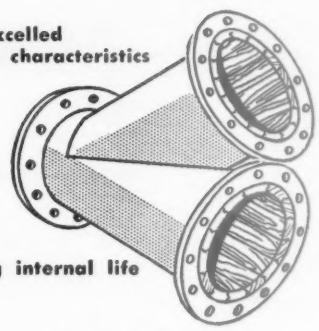
Dr. Paul W. Bachman has been named vice president of The Davison Chemical Corporation. He was formerly director of research and development and will continue in charge of these activities. Dr. Bachman joined Davison in 1949. He is a graduate of Johns Hopkins University.

5 reasons WHY

mpc WOOD-LINED STEEL PIPE IS IMPORTANT TO THE PETROLEUM INDUSTRY

1 Non-corroding

2 Unexcelled flow characteristics



3 Long internal life

4 Unexcelled cushioning capacity against pulsations, vibrations and other mechanical influences

5 Low cost

Combines the strength of steel with the durability of wood. Recommended for salt water lines, desalting service, dilute caustic soda and polysulfide transport, acid wastes, cooling tower service and oil gathering lines. Operating service up to 250 p.s.i. and 180°F. Higher pressure ratings for special service requirements. All pipe flanged and available in 10' and 20' standard lengths or custom fabricated to specifications. Diameters 4" thru 48". Easy to cut and re-flange. All flanges have standard ASME bolt circle.

Wood-lined fittings in standard and special designs for all diameters. For catalog and additional information, write Dept. PE.

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MICHIGAN PIPE COMPANY

Bay City • Michigan

Manufacturers of Wood-Stave, Saran Rubber-Lined, Stainless Steel and Monel Piping

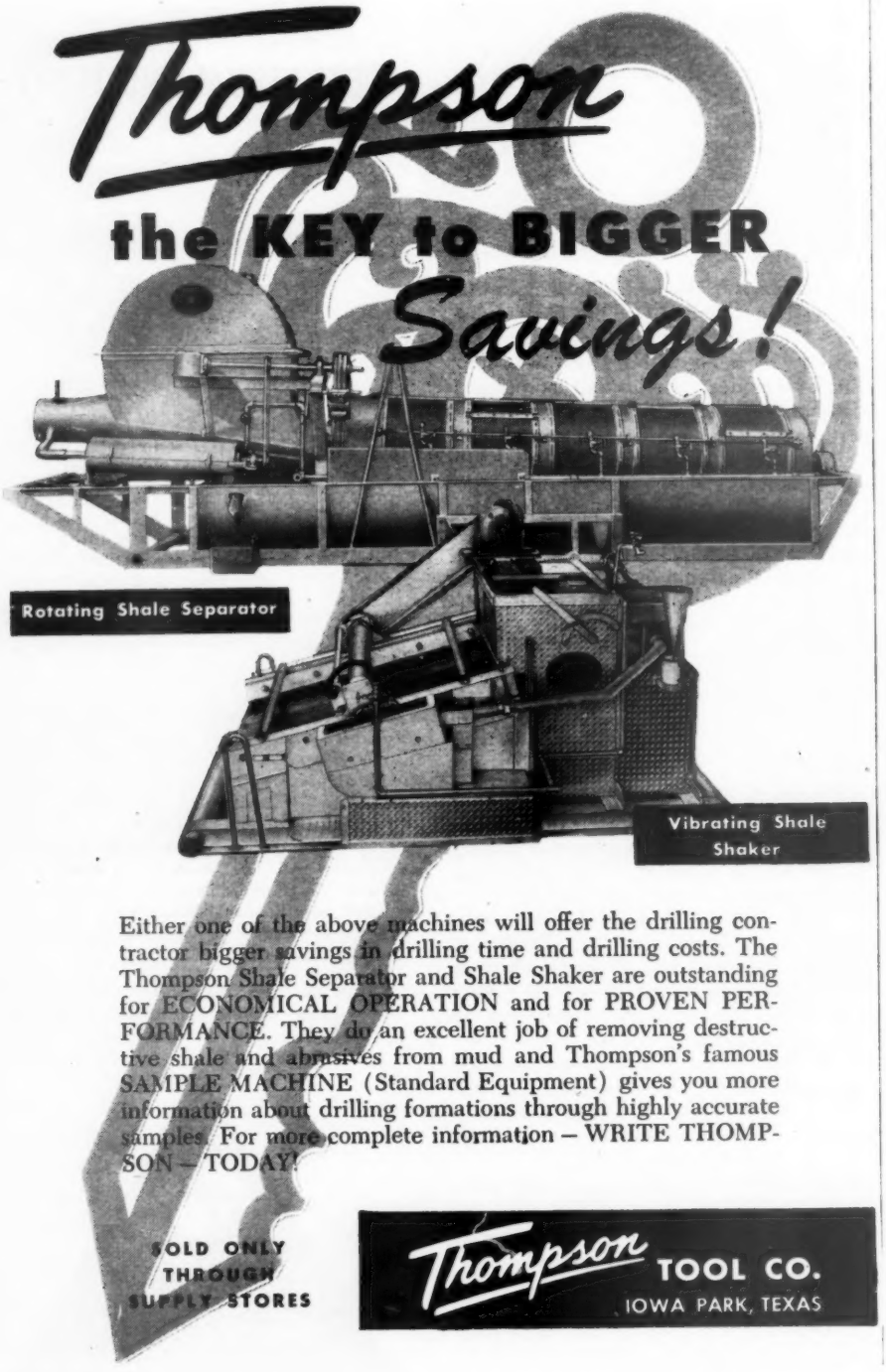
Trade Personals

Luther Evans, director of industrial relations of the Dow Chemical Company's Texas division, has been elected to the board of directors of Dowell Incorporated. Evans replaced **Dr. William R. Veazey,** of Midland, Michigan, on the Dowell board. Dr. Veazey retired in June. Evans first worked for Dow in Midland, Michigan, during summer vacations from Alma College in 1934 and 1935. Following graduation, he joined Dow as a chemist in 1936.

Brock Mott has been named Drayer-Hanson, Inc.'s Gulf Coast distributor for industrial products, particularly Drayer-Hanson boiling point cooling systems and Cal-Fin tubing.

A. H. Honeck has been named district manager in Cleveland and Cincinnati, Ohio, for Graver Water Conditioning Company. Honeck is a graduate mechanical engineer, obtaining his degree from the Rochester Institute of Technology.

Oliver C. Davis, who has been store manager at Artesia, Colorado, has been named as city sales representative in Billings, Montana, for Continental Supply Company. **Edward Cajthaml,** former field salesman in Casper, Wyoming, has taken over the duties as Artesia store manager, while **Ross E. Prowell,** of the Casper store has taken over Cajthaml's former duties.


Thompson
the KEY to BIGGER
Savings!
Rotating Shale Separator
Vibrating Shale Shaker
Either one of the above machines will offer the drilling contractor bigger savings in drilling time and drilling costs. The Thompson Shale Separator and Shale Shaker are outstanding for ECONOMICAL OPERATION and for PROVEN PERFORMANCE. They do an excellent job of removing destructive shale and abrasives from mud and Thompson's famous SAMPLE MACHINE (Standard Equipment) gives you more information about drilling formations through highly accurate samples. For more complete information – WRITE THOMPSON – TODAY!
SOLD ONLY THROUGH SUPPLY STORES
Thompson TOOL CO.
IOWA PARK, TEXAS

Dee Unsell

Earl Darr

Dee Unsell has been named Denver district sales manager of Black, Sivalls & Bryson, Inc. He has been with BS&B for the last 13 years. During that time, he has served BS&B as salesman, and city sales manager at Denver, Colorado.

Earl Darr has been named Shreveport district sales manager. He has been with BS&B for the last 18 years. During that time, he has served BS&B as sales engineer.

Carl L. Erwin, personnel manager of Edward Valves, Inc., has recently been advanced to the position of assistant works manager.

In his new assignment, Erwin will continue to take an active part in employment affairs and industrial relations. Among his specific assignments is the broadening of the company's employee training programs.

Tom Seago has been named manager of Acme Oil Tool and Great Bend Fishing Tool Company's new fishing tool shop in Wichita Falls, Texas. Seago went to work for Acme in 1943 as a fishing tool operator and was promoted to fishing tool superintendent last September, the position he held prior to his new appointment.

Hugo Zimmer, formerly manager of the Iverson Supply Company, Salem, Illinois, store has been transferred to Farmington, New Mexico, as a field salesman.

Ernest Lambert, formerly store manager at Price, Utah, has been transferred to Farmington, New Mexico, as store manager.

Al Iverson, Jr., formerly field salesman, has assumed management of the store at Price, Utah.

John Spain, formerly store man at Salem, Illinois, has been transferred to Farmington, New Mexico, in the same capacity.

Albert H. Borchardt, vice president of Worthington Corporation, has retired after 44 years with the company. Upon his appointment as vice president in July 1951 Borchardt assumed the overall responsibility for the sale of the corporation's entire line of pumping equipment, including centrifugal, reciprocating.

W. Walter Watts has been named vice president in charge of technical products, and **Theodore A. Smith,** vice president in charge of the engineering products department of the RCA Victor Division, Radio Corporation of America.

BOOKS

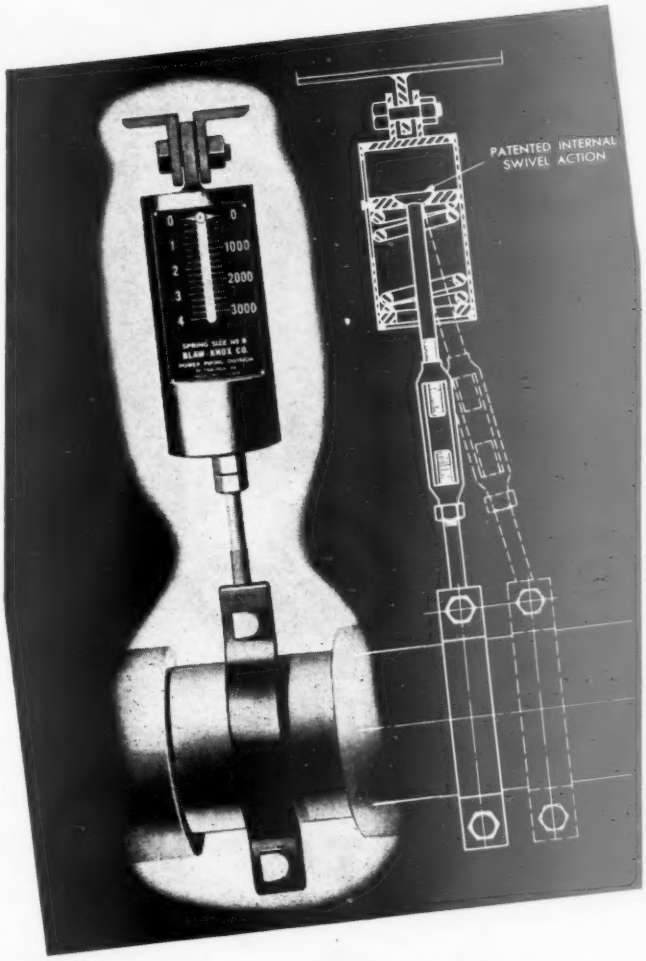
Higher Surveying *(Volume II of Principals and Practices of Surveying)by Breed and Hosmer. Printed by John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, New York. Pages, 675.* ***Price, $7.00.***

This completely revised edition contains changes in all five of its major divisions. In Part I, Control of the Survey, the chapter on barometric leveling emphasizes the latest development in the use of surveying altimeters. Part III, Photogrammetric Surveying, now includes information on the newest methods and instruments for the construction of maps from aerial photographs.

Discussion of astronomical observations now includes text and examples illustrating the Greenwich Hour Angle Method. Full modern treatment is accorded hydrographic surveying and finishing maps.

ASTM — IP Petroleum Measurement Tables, *American Edition; American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pennsylvania. Price, $8.75. Pages, 544. British Edition, Pages, 432. Price, $7.00. Metric Edition, $7.70.*

This most outstanding work needs little introduction to the petroleum and natural gas industries of the world. Developed jointly by the American ASTM and the British Institute of Petroleum to meet an ever more insistent demand, its 39 tables include data covering all conversions given in the six tables National Bureau of Standards Circular C 410. Tables are given to facilitate weight and volume conversions where more than one measuring system is involved. Tables apply to all types of crude petroleum and their products, regardless of manufacturing method. The volume is considered the greatest contribution in this field ever made.



"Ready-Made" for Any Piping Layout

To save engineering time and eliminate expensive cutting, threading and assembling in the field, just specify—

BLAW-KNOX HANGERS

Whether the installation calls for Rigid Hanger Assemblies, Functional Hangers, Vibration Eliminators or Overhead Roller Assemblies, you'll find each furnished as a complete unit designed to do the best job. Blaw-Knox pioneered in this field and has brought to it many improvements in hanger design—including the patent Internal Swivel Action which permits both lateral and longitudinal movement, while the hanger case itself remains vertical. Engineers who have solved some of the toughest hanger problems are available at all times to apply their experience to any installation that presents difficulties.

For complete technical data and time-saving information on hanger locating, send for Catalog No. 51.

BLAW-KNOX COMPANY
POWER PIPING AND SPRINKLER DIVISION
PITTSBURGH 33, PA.

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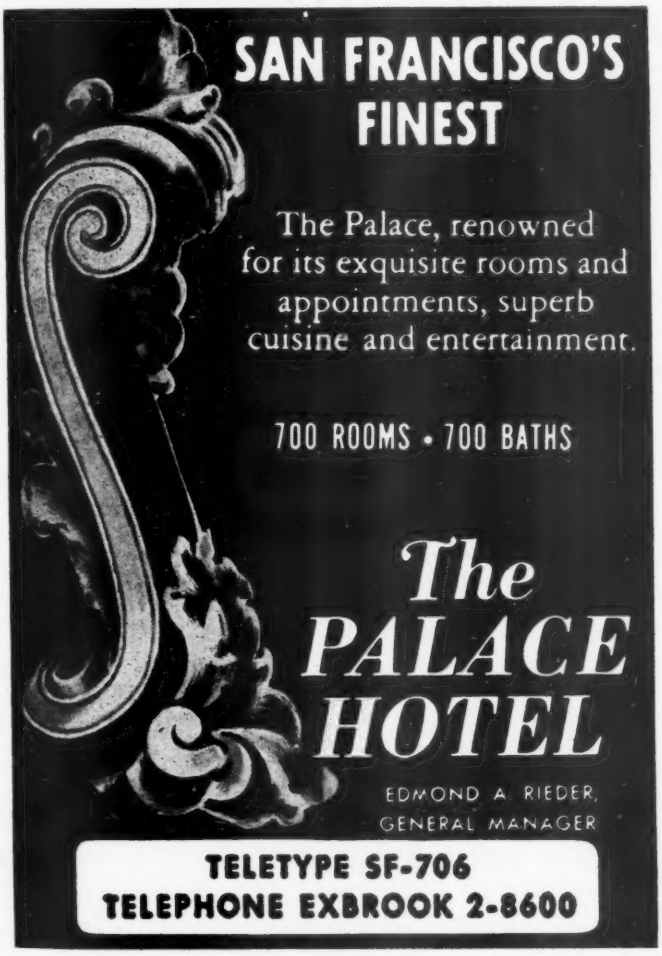
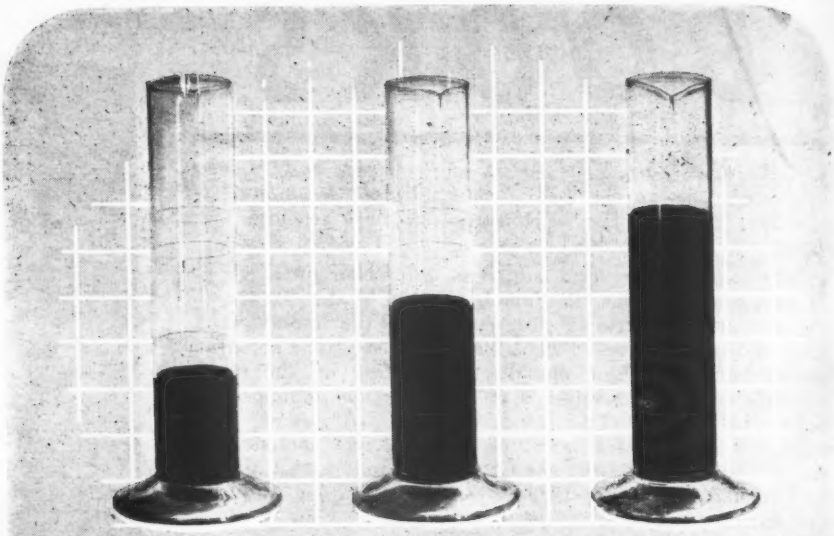

SAN FRANCISCO'S FINEST
The Palace, renowned for its exquisite rooms and appointments, superb cuisine and entertainment.
700 ROOMS • 700 BATHS
The PALACE HOTEL
EDMOND A. RIEDER, GENERAL MANAGER
TELETYPE SF-706
TELEPHONE EXBROOK 2-8600

How *Visco Quality* CUTS YOUR EMULSION-BREAKER COSTS



To Treat the Same Identical Emulsion Required:

3 units of a Visco Class I *high quality* formula.

5 units of a medium-priced emulsion breaker.

7 units of a low-priced emulsion breaker.

In each instance, Visco Class I is the highest-priced chemical—but the lowest in cost per barrel of dry oil!

Quantities above were determined from controlled tests in the field and in the Visco Laboratories. Oil treated contained emulsion which could be satisfactorily broken by all three formulas. This proof of the real economy of Visco Quality formulas is even more dramatic on leases where emulsions encountered are more difficult and sometimes impossible to break with lower grade formulas...

You can put Visco Quality to work on your leases promptly—Call Houston, CAPITOL 7300, collect, for fast action. Remember: By paying too little for treating chemical you may be paying far too much for pipeline oil!

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INCORPORATED
City National Bank Building
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Visco • • • CONSISTENTLY EFFICIENT DEHYDRATING AND DESALTING CHEMICALS

New Machinery and Supplies

Use reply card to procure promptly complete information and prices of products described here in brief.

Circle corresponding letter or letters on reply card

(A) MAGNA STROKE

Closer regulation of fluid flow is made possible through the use of The Thomas Magna-Stroke, a new development in regulating valve design introduced by the Natural Gas Equipment Inc. Magna-Stroke is available in all types of NGE Wilgus regulating valves. Magna-Stroke is a gear train working at a ratio of 2:1, giving twice the stroke at the inner valve as at the diaphragm.

Circle letter (A) on reply card.

(B) DIESEL ENGINES

Mack Trucks, Inc. announces the introduction of a new diesel engine, the Mack Thermodyne Model END-673. Manufactured in Mack factories, specifically for installation in Mack vehicles, this new engine develops 170 bhp at 2100 rpm. Torque output is 480 lb ft. maximum, at 1200 rpm.

Circle letter (B) on reply card.

(C) WATER CANS, COOLERS

The tops of all Igloo water cans and coolers now have a "new look," obtained by precision die-forming the inner liner to the crown. The new forming process, done under forty tons of hydraulic pressure, provides four thicknesses of metal at this joint, making it absolutely leak-proof and adding strength to keep the top opening perperfectly round.

Circle letter (C) on reply card.

Bettis Corporation Igloo Water Can.

(D) PIPE INSULATION

Gustin-Bacon Manufacturing Company announces a new one-piece molded fine glass fiber pipe insulation—G-B Ultrafine pipe insulation. Among the features of the new product, are the following: (1) Exceptional thermal efficiency (2) Light weight (3) Flexibility (4) Resilience (5) Non-breakable, and many others.

Circle letter (D) on reply card.

(E) PILOT LOADING SYSTEM

A new "pilot loading system" designed to increase the safety and versatility of its standard "014" regulators has been introduced by Rockwell Manufacturing Company. A "pilot-loaded" regulator of this type, the manufacturer reports, can deliver more than three times the outlet pressure obtainable with a standard weight loaded regulator.

Circle letter (E) on reply card.

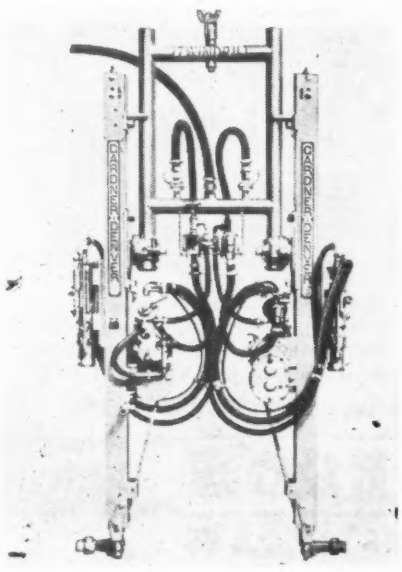
(F) ROCK DRILL

The Gardner-Denver Twindril, the pipeliner's rock drill now has a new feature, according to reports from the manufacturers, Gardner-Denver Company.

The Twindril is a complete rock drilling unit which is quickly hung from the side boom of a pipe line tractor, and is powered by compressed air from a portable air compressor which is towed along behind the tractor.

Circle letter (F) on reply card.

Gardner-Denver Rock Drill



(G) TRUCK TANK DOME

A new truck tank dome of greatly improved design is now being manufactured by Shand and Jurs Company. It

has a very low silhouette, is extremely rugged yet light in weight, and possesses safety features newly incorporated in truck tank domes. One safety feature is the safety catch on the S&J truck tank dome.

Circle letter (G) on reply card.

(H) TUBE TESTING

Tube Testers, Inc. has announced a new device for testing leaks in tubing. A new pressure method known as Hyrdo-Test developed by Tube Testers is reported to check tubing under hydraulic pressure, finding all leaks while tubing is being run back into the well, eliminating defective tubing and increasing overall efficiency.

Circle letter (H) on reply card.

(I) FLASH WELDING

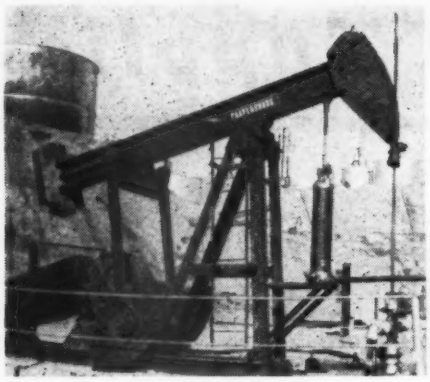
Reed Tool Joints, flash welded to drill pipe, have been added to the Reed line of tool joints, according to an announcement by Reed Roller Bit Company. Full hole, semi-internal flush and internal flush types are available, with either the conventional square shoulder or with 18 deg taper. All Reed tool joints have pre-lubrication infused into the threads to prevent galling.

Circle letter (I) on reply card.

(J) LINE PURIFIERS

Of unusual interest to executives, superintendents, and engineers of pipe line companies and pipe line contractors is a new Hi-eF purifier designed for use on natural gas lines. Purpose of this purifier is to provide an economical means of removing wet and dry particles in natural gas lines at compressor stations.

Circle letter (J) on reply card.



King Pump Vacuum Pump

(K) VACUUM PUMP

King Pump Company has announced its new vacuum pump can be installed on any type of surface pumping unit, and can be operated by the same power supply as the pump jack. It will establish and hold vacuum desired up to 27 in. of a 30-in. barometer reading. Design is such that with each stroke of the pump air passes by the cup-shaped piston and prevents excessive heating.

Circle letter (K) on reply card.

(L) CRAWLER SHOVEL-CRANE

Schield Bantam Company has announced the introduction of a new 3/8-yard, 5-ton rated crawler-mounted line of cranes, back hoes, draglines, shovels, clam-shells, pile drivers and magnet cranes. Model designation of the new crawler is the "C-35". The Schield Bantam Company reports that they are now in full production of the new crawler-type machine as well as in continued production of the truck-mounted Bantam.

Schield Bantam Shovel Crane

Circle letter (L) on reply card.

(M) INDUSTRIAL ENGINES

Production of a new heavy duty industrial engine known as the K-67 has been announced by The Climax Engine and Pump Manufacturing Company. The new model, latest in the Climax Blue Streak series, was designed to provide power for oil well drilling, water pumps, generators, blowers, snow plows, mud pumps, cranes, and compressors. It has six cylinders.

Circle letter (M) on reply card.

(N) EXTRACTING TOOL

A new extracting tool that removes threaded broken parts without wedging them into place is now being marketed by the Roddick Tool Company. The extractor is made to work with any fitting in the pipe, hydraulic, aircraft, plumbing, or mechanical fields and is now available in a range of 20 sizes. Sizes 1/8 to 7/8 by 1/32 in. complete the Roddick extractor line.

Circle letter (N) on reply card.

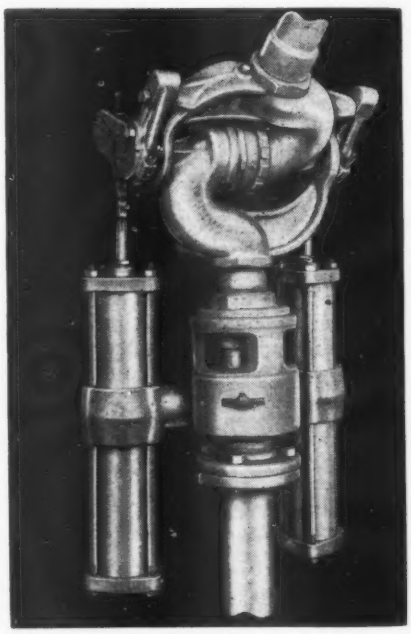
(O) BRIDGING PLUG

Reduction of time required for the drilling of either cast iron or magnesium bridging plugs, set as temporary bridges, has been achieved in a number of fields, according to reports received by Lane-Wells engineers. Lane-Wells bridging plugs, set on wire line, are designed for either permanent or temporary bridges. The plug is equipped with a ram adapter, which transmits the downward reaction from the setting tool to the slips.

Circle letter (O) on reply card.

(P) SWING JOINT

To reduce friction and to promote greater ease and flexibility in handling, a newly styled swing joint equipped with Timken tapered roller bearings is now



available in Oilco loading assemblies. This innovation, studied, tested, and perfected with the aid of Timken engineering guidance, brings forth a swing joint capable of extreme load capacities.

Circle letter (P) on reply card.

(Q) SWING CHECK VALVES

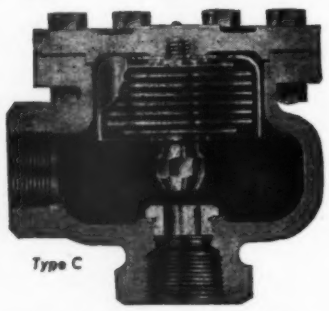
A new line of improved swing check valves at no increase in price has been developed by the Charles Wheatley Company in collaboration with the Frank Wheatley Pump and Valve Company. The new Streamflo synthetic seal check valve, which weighs 50 per cent less than the best standard check valve, is full pipe opening allowing scraper room.

Circle letter (Q) on reply card.

Nicholson Steam Traps

CUT KETTLE TIME 30%

for Leading Processor



Type C

Records of a recent installation of Nicholson steam traps, by a large processor, show they cut kettle time 30%. For example, one operation was shortened from 65 to 45 minutes. Nicholson units keep equipment full of live steam because: 1) they operate on lowest temperature differential; 2) have 2 to 6 times average drainage capacity; 3) maximum air-venting capacity. See why leading plants are increasingly standardizing on Nicholsons.

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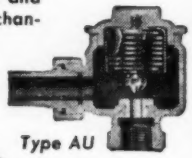

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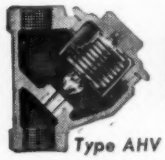
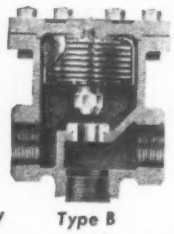


Type AHV



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W. H. NICHOLSON & CO.

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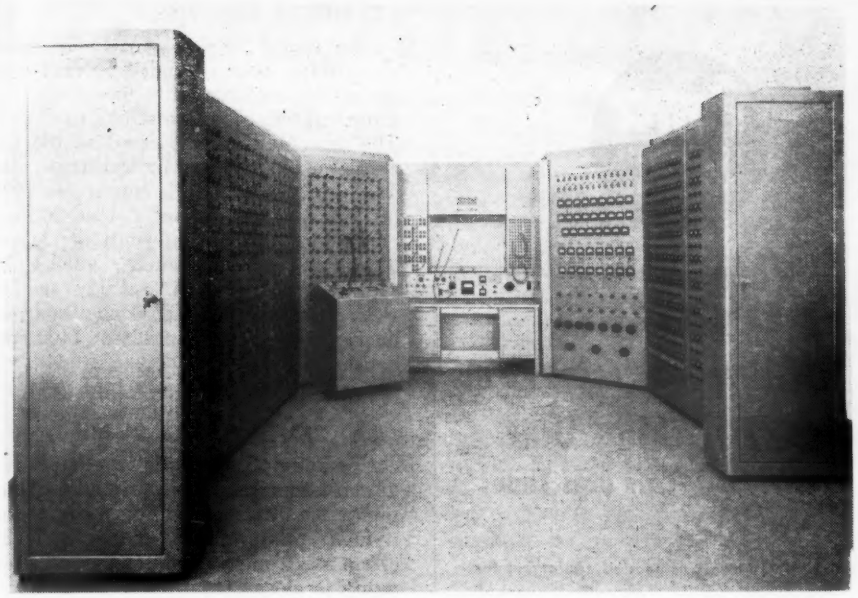

Standard Electric's New Fluid Network Analyzer.

(R) FLUID NETWORK ANALYZER

The Standard Electric Time Company was host recently to a group of engineers and officials representing several gas and water industries, invited to witness a demonstration of the first McIlroy fluid network analyzer ever built for a gas company. The piece of equipment was designed and built by Standard for Laclede Gas Company of St. Louis and has a capacity of 491 pipes, 180 fully automatic loads and 26 sources. The analyzer is an analogue computer designed for analyzing fluid networks.

Circle letter (R) on reply card.

(S) GLASS PAPER

Papers made of extremely fine fibers of glass are being used in a variety of industrial specialty applications, Owens-Corning Fiberglas Corporation has announced. These incombustible, inorganic industrial papers are being used for the filtration of hot and/or corrosive air, gases, and liquids.

Circle letter (S) on reply card.

(T) SPROCKET WHEELS

A new line of roller chain sprocket wheels with taper lock bushings, facilitating immediate delivery and rapid installation, has been announced by Link-Belt Company. Without reboring, these stock sizes of sprocket wheels can be securely mounted on a shaft, equivalent to a shrink fit. Action of the taper lock bushing assures tight fit within the full range of normal shafting tolerances.

Circle letter (T) on reply card.

(U) PORTABLE INSTRUMENTS

Two series of improved portable electric instruments designed for maximum convenience and readability have been announced by the General Electric Company's meter and instrument department. The new instruments, Type DP-11 and DP-12 are available to indicate volts, watts, amps, and milliamps.

Circle letter (U) on reply card.

(V) RIGS

A small rig, designed primarily for well servicing and workover jobs, is drilling wells up to 2500 ft deep for the Welker Oil Company. It is an Ideal Type T-8 hoist, manufactured by The National Supply Company and was the first of this type to be put in service. In addition to the draw works, the rig includes a 6-cylinder diesel engine with torque converter, an Ideal Type V swivel, an Ideal FE 17½-44 rotary.

Circle letter (V) on reply card.

(W) WELLCHECKER UNIT

The new Rolo Wellchecker Unit No. 1H-3006 was especially designed for testing in "water flood projects," and in fields where little or no gas is produced. Rolo free water knockout units are available in a number of different sizes. Unit No. 1H-3006, is recommended for 900 bbl liquid per day, with ten minute retention time.

Circle letter (W) on reply card.

(X) CORROSION INHIBITOR

Solvay Process Division, Allied Chemical and Dye Corporation has announced a new product "Nitrox," which it describes as a combination cleaner-corrosion inhibitor used for cleaning iron and steel cargo tanks in tankers and for other containers handling light hydrocarbons, inedible oils, solvents, and inorganics.

Circle letter (X) on reply card.

(Y) ELECTRIC PLUG

Getting power from overhead busway to machines below has been made easier and faster by an improved device recently developed by the Trumbull electric department of the General Electric Company. According to T. D. MacLafferty, Trumbull marketing manager, the new device, called an FG Flex-A-Plug, is designed for use with the Trumbull Flex-A-Power distribution system.

Circle letter (Y) on reply card.

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The 25 hp. Model VF4 Wisconsin Air-Cooled Engine supplies power for all operating phases — road mobility, climbing up and over rails, operating hydraulic lift that "couples" the unit to the car, handling all switching maneuvers with a 7400-lb. drawbar pull applied to 4-wheel drive . . . moving up to 3 loaded tank cars at a time, at a rail speed of 150 ft. per minute!

It's another typical Wisconsin Heavy-Duty Air-Cooled Engine application, illustrating how these fine engines fit a great variety of *jobs* and *machines* . . . including many oil field utility units.

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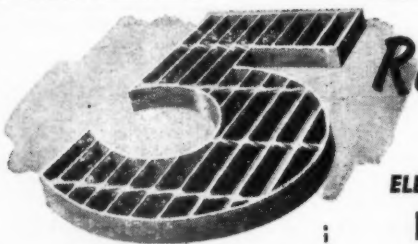

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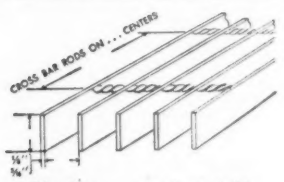

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Please send prices on_____Type_____Stair Treads_____inches wide.

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CITY_____ZONE____STATE_____

BLAW-KNOX ELECTROFORGED STEEL GRATING

New Equipment

(Z) DIESEL ENGINES

The power range of Murphy diesel engines has been extended upward with the addition of four new models having a bore of 6⅜ in. and a stroke of 6½ in. The new Model 24 is rated at 185 hp, continuous, 20 hp, intermittent; the Model 124 at 210 hp, continuous, 225 hp intermittent; Model 224 at 200 hp, continuous, 215 hp, intermittent; Model 324 at 225 hp, continuous, 240 hp, intermittent. Models 24 and 124 are designed to operate at 1200 rpm continuously; Models 224 and 324 at 1400 rpm continuously.

Circle letter (Z) on reply card.

(AA) CENTRIFUGAL PUMP

Chempump Corporation announces its new fractional horsepower model Chempump, a radically new approach to centrifugal pump design that practically eliminates pump maintenance. Chempump is closed from the atmosphere.

Circle letter (AA) on reply card.

(AB) PRESSURE SWITCH

Model 9612, a new heavy duty pressure switch developed by Barksdale Valves, is capable of sensing any system pressure over an adjustable range from 15 to 3000 psi and actuating an electrical circuit on increasing or decreasing pressure. The piston type pressure sensing element is not subject to fatigue.

Circle letter (AB) on reply card.

(AC) SLIDE VALVE MANDRELS

Two new types of mandrels for gas lift valves permit the communication port between the tubing and the gas lift valves to be opened or closed by wire line tools. The mandrels contain an internal slide valve, fitted with O-Ring sealing members, that may be moved to "open" position whenever it is necessary to gas lift the well, and moved to "closed" position when gas lift is not required.

Circle letter (AC) on reply card.

(AD) PIPE LINE DRILL RIGS

Le Roi Company is offering a new pipe line drill rig available in the Le Roi-Cleveland Model SB 30 Pipeliner Special. Equipped with adjustable boom arms the SB 30 will be provided with two, three, or four drills, in either the heavy duty four-inch class or the lighter three inch class, for mounting on any suitable crawler tractor.

Circle letter (AD) on reply card.

(AE) WATER SUCTION HOSE

A new horizontal braided water suction hose, Revolc water suction hose, has been developed by Quaker Rubber Corporation, Division of H. K. Porter Company, Inc. Revolc water suction hose is especially designed for both pressure and suction handling of water. The hose is reinforced with two layers of braided rayon cord, plus a helix of high tensile spring steel wire.

Circle letter (AE) on reply card.

Trade Literature

Publication will be sent free.

(AF) PRESSURE SWITCHES

Barksdale meletron pressure switches are described in a bulletin published by Barksdale Valves. Various models of the pressure-actuated, vacuum-actuated switches are described with assorted facts about each. Low and high pressure specifications are included in chart form along with electric ratings.

Circle letter (AF) on reply card.

(AG) CHLORINE DISPENSER

F&P Catalog 61 (12 pages) describes the new solution feed dry vacuum type Fig. 1050 Ratochlor chlorine dispenser, giving specifications covering dispensing rates from 0.5 ppd to 1000 ppd. Also found in the catalog are illustrations of component parts, a complete flow diagram of the dispenser, and pictures of chlorine dispenser installations.

Circle letter (AG) on reply card.

(AH) LINE BLIND VALVE

Hamer Oil Tool Company has published a 4-page bulletin describing the Hamer line blind valve. A cross section of the valve "Fluid Savers," show the telescoping hubs that slide one within the other. The three operating bolts provide an effective means for clamping the spectacle plate tightly and are quickly turned by means of a straight bar.

Circle letter (AH) on reply card.

(AI) OXYGEN MEASUREMENT

Arnold O. Beckman, Inc. has issued a new bulletin describing an instrument that measures oxygen content directly without using filaments, catalysts, chemicals, or other secondary methods of measurement. Known as the Arnold O. Beckman Model F-3 oxygen analyzer, this new instrument makes a direct physical measurement on the oxygen content of the sample gas.

Circle letter (AI) on reply card.

(AJ) OIL FIELD EQUIPMENT

A new market brochure "New Performance In The Oil Field" has been released by the tractor division of the Allis-Chalmers Manufacturing Company. In two-colors, black and Persian orange, the brochure shows the various applications of crawler tractors and motor graders with allied attachments.

Circle letter (AJ) on reply card.

(AK) CORROSION RESISTANCE

The corrosion engineering department of the Pennsylvania Salt Manufacturing Company has prepared a comprehensive chart showing the resistance of seven classes of corrosion resistant cements to 297 of the most generally used corrosive chemicals. The chart indicates that Pennsalt has a cement mortar that is resistant to chemical attack of all these chemicals except sodium hypochlorite.

Circle letter (AK) on reply card.

(AL) OIL INDUSTRY HOSE

A new, fully illustrated 8-page booklet describing the types of hose produced for the oil industry by Quaker Rubber Corporation, division of H. K. Porter Company, Inc. is now ready for distribution. Some of the oil hoses described in the bulletin are barge loading, oil suction, and discharge (both smooth bore and rough bore), butane-propane, fuel oil, gasoline pump, etc.

Circle letter (AL) on reply card.

(AM) VACUUM GAGES

A new 32-page catalog No. 7001 describing many types of pressure and vacuum gages used to measure vacuums as greats as 10^{-11} mm of mercury and pressures as high as 150,000 psi, has been published by Minneapolis Honeywell Regulator Company. Catalog covers indicators, recorders, pneumatic and electric controllers, etc.

Circle letter (AM) on reply card.

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Trade Literature

(AN) MOTOR STARTERS

Allis-Chalmers size 0-3 ac cross-the-line motor starters are described in a new eight-page bulletin released by the company. The bulletin covers manual and magnetic types of starters, and combination and reversing starters as well as push button control stations.

Circle letter (AN) on reply card.

(AO) GAS-OIL RATIO COMPUTATIONS

Detailed procedure for conducting gas-oil ratio tests of well production is covered in a new six-page application engineering data sheet, issued by The Foxboro Company. By means of a sample problem, the publication outlines the step-by-step flow calculations, based on pressure measurements from a portable recording instrument.

Circle letter (AO) on reply card.

(AP) TESTING MANUAL

A new 50-page manual on practical insulation resistance testing has been issued by Associated Research, Inc. Designed around the use of Vibrotest insulation resistance testing instruments, the manual covers virtually the entire field of insulation resistance testing in a plain language, how-to-do-it style.

Circle letter (AP) on reply card.

(AQ) GAS GRAVITOMETERS

In a new bulletin just issued by American Recording Chart Company, featuring its complete line of gas-gravitometer instruments, the new recording gas gravitometer is featured. This instrument may be used for either recording transmitting or for recording controlling.

Circle letter (AQ) on reply card.

(AR) CABLE, HYDRAULIC DOZERS

A new catalog showing the 15 models of cable and hydraulic dozers and 3 models of control units available for Allis-Chalmers tractors has just been announced by Gar Wood Industries. Inc. This new catalog is extensively illustrated with cut-aways, engineering drawings, detailed, and on-the-job photos.

Circle letter (AR) on reply card.

(AS) SPROCKET CHAIN

An "Abbreviated Catalog" on Rex cast and steel chain, cast tooth sprockets, belt conveyor idlers, and spray nozzles has just been released by Chain Belt Company of Milwaukee. It is intended for designers of equipment using sprocket chains and power transmission machinery and purchasers of material.

Circle letter (AS) on reply card.

(AT) HYDRAULIC DRIVES

To introduce five new friction and hydraulic drives for powered equipment used in the major industries, Twin Disc Clutch Company has released a special 16-page "New Products" issue of Production Road, its house magazine. The new Twin Disc drives and the purpose of their development include a two-stage hydraulic torque converter.

Circle letter (AT) on reply card.

(AU) ENGINES

Publication of a new eight-page, two color bulletin containing construction and operating data on Nordberg four-cycle Supairthermal V-Type stationary or marine engines is announced by Nordberg Manufacturing Company. Nordberg 13 in. bore and 16½ in. stroke Supairthermal V-Type engines as described in Bulletin 197 are built to meet the increasing demand for a high power, heavy duty diesel.

Circle letter (AU) on reply card.

(AV) METAL-ARC WELDING

An 8-page reprint entitled "Will Inert-Gas Metal-Arc Save Money on Mild Steel" is being offered by Air Reduction Sales Company. Reprinted from *The Welding Engineer* and written by G. C. Christopher and R. C. Becker of the research laboratories of International Harvester Company, this article reports the results of weld tests on mild steel with the inert-gas metal-arc welding method.

Circle letter (AV) on reply card.

(AW) PERFORATORS

A new, 32-page, 2-color booklet "How To Get More Oil" has just been released by McCullough Tool Company. This new booklet gives a complete description of improvements and latest results with McCullough perforators. A large portion of the booklet is devoted to a complete report and analysis of surface penetration tests.

Circle letter (AW) on reply card.

(AX) DOWNFLOW PURIFIER

A new comprehensive bulletin has recently been published on Anderson internal downflow Hi-eF purifiers for steam drums, flash tanks, evaporators, packed towers, deodorizers, stills, bubble-cap towers, receivers. An unusual feature of this bulletin is two pages of selection tables that guide the user in selecting purifiers for any steam, air, gas or vapor installation.

Circle letter (AX) on reply card.

(AY) ORIFICE METERS

A comprehensive 28-page bulletin describing Rockwell "201" orifice meters has just been issued by Rockwell Manufacturing Company. Featured in the new bulletin are 3½ pages of tables giving representative orifice capacities —offering the measurement man in the field time-saving help in sizing orifice meter plates.

Circle letter (AY) on reply card.

(AZ) CENTRIFUGAL PUMPS

A new bulletin covering its line of SESC (standard end suction centrifugal) pumps is now being offered by Worthington Corporation. The SESC pumps provide an over all line of centrifugal pumps covering the widest variety of applications and offering maximum interchangeability of parts. The line covers six types of pumps with varieties of mountings, frame and drives.

Circle letter (AZ) on reply card.

Trade Literature

(BA) DRILLING RIGS

The National Supply Company has published a 2-color, 14-page bulletin describing its Ideal rigs. The bulletin takes the Type-8 and the Type-8-S hoists, and describes their construction including: Drum shaft assembly, drum brakes and brake rims, drum clutch, rotary drive, and wire line anchor. It describes and illustrates controls on these two hoists and in the back of the bulletin includes performance charts, dimensional drawings, and engineering specifications. It is completely illustrated.

Circle letter (BA) on reply card.

(BB) DRILL BIT SELECTOR

Koebel Diamond Tool Company has published a 16-page, 2-color bulletin on the Koebel diamond core and drill bit selector. Described and illustrated are solid crown bits, insert-type bits, Dia-Pak impregnated bits, Ripper step bits, non-coring, casing and casing shoe, and oil field bits, and reaming shells. Koebel diamond bits when retired from service may be returned to the company for resetting. Worn Koebelite bits yield a high percentage of usable diamonds, and with the usable ones are added new ones, remounted and sent to the user.

Circle letter (BB) on reply card.

(BC) SEAL-O-RINGS

Grove Regulator Company has published a very unusual type bulletin describing its Seal-O-Ring. The booklet contains multi-color diagrams, and concise descriptions of the valves' operation. The Grove Seal-O-Ring is said to apply the simple physics of a precision finish port-plate sliding within dual sealing rings, with the effective metal-to-metal seal augmented by dual "O" rings.

Circle letter (BC) on reply card.

(BD) OIL FILTERS

Told in story form is the tale of Angus McFrugal who learned to use Winslow filters. The leaflet was published recently by Winslow Engineering Company. Along with the comic-style folder is another folder of more serious nature describing fuel filtration of diesel, gasoline, and other refined fuels, natural gas, sewage gas, and other gaseous fuels. The Winslow fuel is said to take out the dirt and sludge and water and harmful properties, without bothering the detergents.

Circle letter (BD) on reply card.

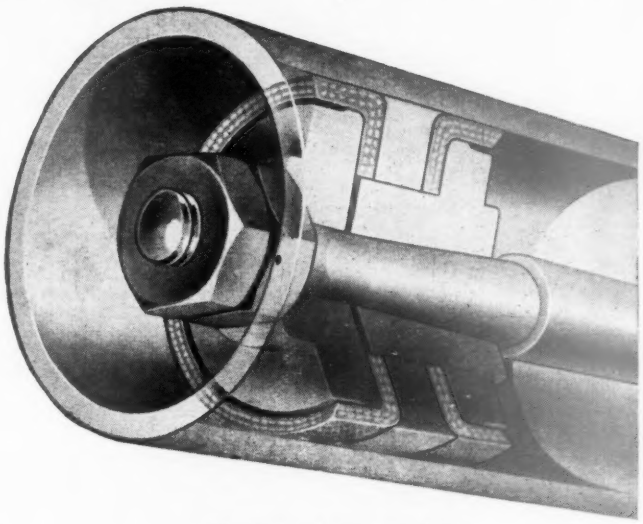
(BE) GRAVITOMETER CHART RANGES

American Recording Chart Company has published a new bulletin on "Gravity Instruments for Specific Gravity of Liquids." The bulletin is profusely illustrated and describes the various types of gravitometers for use on products pipe lines, for transmitting liquid gavitometer, etc. Also described is the Arcco-Anubis recording controlling liquid gravitometer for pipe line, refinery, industrial control, food, chemical, others.

Circle letter (BE) on reply card.

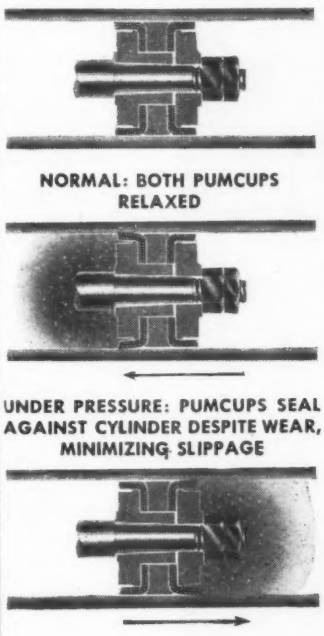
DARCOVA PUMCUPS

more efficient...job after job!



Phantom cutaway showing a typical Pumcup piston assembly.

DIAGRAM OF DARCOVA PUMCUP ACTION (greatly exaggerated)



NO matter how tough your pumping problem Darcova Pumcups can help solve it . . . this has been proved in thousands of plants year after year.

Darcova Pumcup Advantages

1. Texture engineering that not only increases volumetric efficiency, but keeps it high with no appreciable fluid slippage for the entire life of the Pumcups.

2. Darcova Composition Pumcups give many times the life of other types of piston packing . . . *at least 3 to 1!*

3. Standard or special compositions are available for exceptional stability in handling almost *any* fluid . . . strong acids, alkalies, food products and even troublesome petroleum derivatives.

Send For Free Bulletin—Ask for Bulletin No. 4401 on Pumcups for reciprocating pumps; Bulletin No. 4502 on Pumcups for air and hydraulic mechanisms. Address . . .

DARLING VALVE & MANUFACTURING CO.

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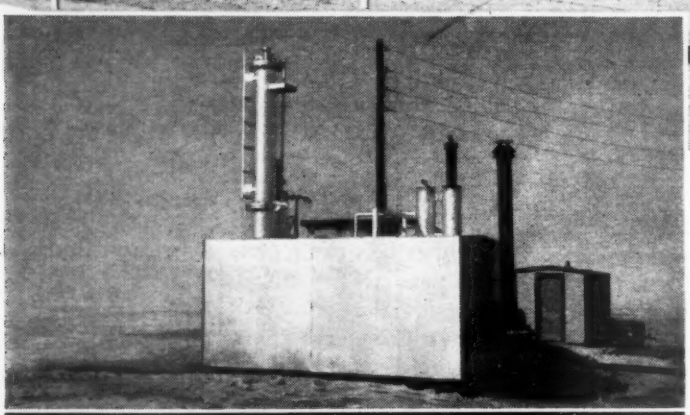
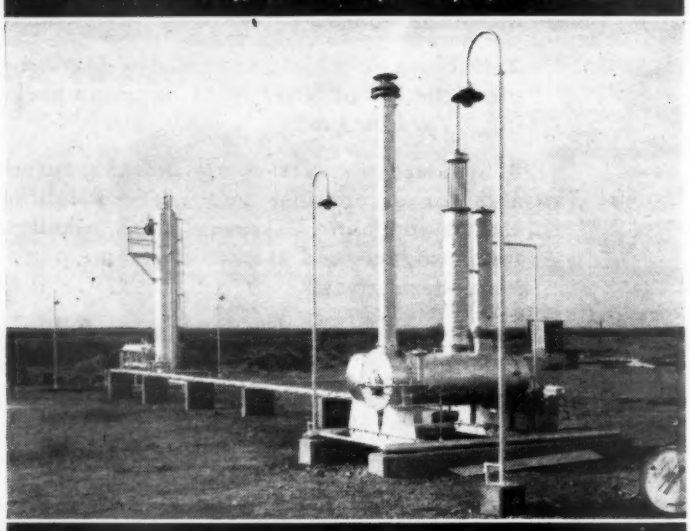
DARCOVA ® THE ORIGINAL COMPOSITION CUP

PUMCUPS

NATIONAL GLYCOL DEHYDRATION AND LOW TEMPERATURE EXTRACTION (LTX®) Equipment



National 500 mcf/day, 125 # WP Glycol Dehydrator — N. Dakota



National 17 mmcf/day, 1000 # WP Glycol Dehydrator — Kansas

A 30" x 12½', 1200 psi LTX with Glycol Injection and a 24" x 15', 300 psi Stabilizing Desorber for 10,000 mcf per day operating on lease in South Texas.

This producer is realizing

MAXIMUM DOLLAR RECOVERY FROM HIS RESERVOIR

It's a National®

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TULSA, OKLAHOMA

6-6-53